

## Appendix C5. Water Temperature Monitoring

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### CONTENTS

C5.1	General Water Temperature Monitoring.....	C-109
C5.1.1	1994-1995 Water Temperature Monitoring Program.....	C-109
C5.1.1.1	Objectives .....	C-109
C5.1.1.2	Methods .....	C-109
C5.1.1.3	Results .....	C-110
C5.1.2	Water Temperature Monitoring Program (1996 to the Present) .....	C-111
C5.1.2.1	Objectives .....	C-111
C5.1.2.2	Methods .....	C-133
C5.1.2.3	Results .....	C-134
C5.1.2.4	Discussion.....	C-134
C5.1.2.5	Conclusions .....	C-135
C5.1.3	References .....	C-135
C5.2	Class II Paired Watershed Temperature Monitoring .....	C-137
C5.2.1	Retrospective Study .....	C-137
C5.2.1.1	Objectives and Methods .....	C-137
C5.2.1.2	Results .....	C-139
C5.2.2	Before-After-Control-Impact (BACI) Water Temperature Study .....	C-140
C5.2.2.1	Objectives and Methods .....	C-140
C5.2.2.2	Results .....	C-145
C5.2.2.3	Discussion.....	C-151
C5.2.2.4	Conclusions .....	C-152
C5.2.3	References .....	C-152
C5.2.4	Attachment A to BACI Class II Temperature Monitoring .....	C-153
C5.2.4.1	Ordinary Least Squares Parameter Estimation.....	C-153
C5.2.4.2	Auto-correlation Modeling .....	C-154
C5.2.4.3	Weighted Linear Regression.....	C-154

### Figures

Figure C5-1.	Five study sites shown below with smoothed daily water temperature profiles computed from the mean of all four temperature probes (i.e. upstream and downstream from the treatment and control streams). .....	C-143
Figure C5-2.	Estimated means at D1120 where no harvest has occurred.....	C-148
Figure C5-3.	Estimated means before and after harvest from the BACI model adjusted for auto-correlation.....	C-149

## Tables

Table C5-1.	Watersheds and number of reaches in 1994-1995 temperature monitoring program. ....	C-110
Table C5-2.	Summer water temperature monitoring summary, Smith River HPA. ....	C-112
Table C5-3.	Summer water temperature monitoring summary, Coastal Klamath HPA. ....	C-116
Table C5-4.	Summer water temperature monitoring summary, Blue Creek HPA. ....	C-119
Table C5-5.	Summer water temperature monitoring summary, Interior Klamath HPA. ....	C-120
Table C5- 6.	Summer water temperature monitoring summary, Redwood Creek HPA. ....	C-121
Table C5-7.	Summer water temperature monitoring summary, Coastal Lagoons HPA. ....	C-122
Table C5-8.	Summer water temperature monitoring summary, Little River HPA. .	C-124
Table C5-9.	Summer water temperature monitoring summary, Mad River HPA. .	C-126
Table C5-10.	Summer water temperature monitoring summary, North Fork Mad River HPA. ....	C-129
Table C5-11.	Summer water temperature monitoring summary, Humboldt Bay HPA. ....	C-131
Table C5-12.	Summer water temperature monitoring summary, Eel River HPA. ...	C-132
Table C5-13.	List of uncut and cut tributaries with watershed area (acres), stream orientation (aspect in °), adjacent stand age (years for uncut, feet for cut), and cover type (RW=redwood, DF=Douglas-fir), mean and mean maximum water temperature (°C) with standard deviations. ....	C-138
Table C5-14.	List of streams used in the BACI study, with stream reach length, mean canopy closure throughout the reach, and aspect. ....	C-142
Table C5-15.	Yearly estimated mean maximum downstream-upstream temperature differences of five study sites. ....	C-147
Table C5-16.	Estimated average maximum temperature differences before and after harvest on four study sites. ....	C-147

## **C5.1 GENERAL WATER TEMPERATURE MONITORING**

### **C5.1.1 1994-1995 Water Temperature Monitoring Program**

#### **C5.1.1.1 Objectives**

- Document diurnal and seasonal temperature fluctuations;
- Determine maxima and duration of daily peak water temperatures; and
- Identify stream reaches with temperatures that may exceed the thresholds of juvenile salmonids (especially coho salmon).

#### **C5.1.1.2 Methods**

Water temperatures were recorded with HOBO® (Onset Computer Corp.) temperature recorders. These devices automatically recorded temperatures at specified time intervals and were left in use for extended periods (up to six months). Two different models were deployed in 1994 and 1995; the HOBO® HTI -05/37°C with an accuracy of  $\pm 0.2^{\circ}\text{C}$  and the HOBO® HTI -37/46°C with an accuracy of  $\pm 0.5^{\circ}\text{C}$ . No attempt at calibration was made during the first two years of temperature monitoring. The manufacturer's specifications were well within the expected requirements of the temperature monitoring. Each thermograph is capable of recording approximately 1800 data points. The length of deployment depends on the selected recording interval. A recorder launched at a 0.8 hr interval will have to be downloaded and restarted within 45 days and thus runs a risk of missing a peak temperature while the recorder is out of the water. An interval of 1.2 hours records 20 temperatures per day and will last 90 days until the memory is full. The hottest three months of the year (July, August and September) were targeted as the summer monitoring window. To test the assumption that a 1.2 hour interval was enough to catch the entire diurnal range in 1994 three thermographs were launched at an interval of 0.6 hours and placed "piggy-back" on thermographs launched at 1.2 hour intervals. A third data set at 2.4 hours was created by deleting every other record in the 1.2 hr. data set. The 1.2 hour interval accurately represents average temperatures but has the potential to miss the absolute extremes by up to two or three tenths of a degree. Since this is within the accuracy of the thermograph ( $\pm 0.2^{\circ}\text{C}$ ) it was determined for practical reasons (i.e. deployment length of 90 days) that 1.2 hours was adequate.

The HOBO®s were typically deployed in the upper, middle and lower reaches of the larger streams with fewer HOBO®s in smaller streams. Actual site selection often depended upon property ownership and access issues. In larger streams the lowest monitoring site in the watershed would frequently be just inside Green Diamond's property boundary. The placement of each HOBO® was in the thalweg of a riffle or the head of a pool where water was mixed (to avoid thermal gradients). The HOBO®s were started between mid- June and early July and recorded temperatures throughout the summer months. They were removed between late September to early November. Time intervals of either 1.2 or 0.8 hours were used to accurately capture both diurnal temperature fluctuations and daily maximum temperatures. During the summer of 1994, 40 HOBO® temperature recorders were placed in fish bearing stream reaches

distributed throughout Green Diamond's California property in areas that reflect a wide variety of stream conditions. In 1995, 28 Class I reaches were monitored (Table C5-1).

**Table C5-1. Watersheds and number of reaches in 1994-1995 temperature monitoring program.**

<b>Watershed</b>	<b>No. of Reaches Monitored in 1994</b>	<b>No. of Reaches Monitored in 1995</b>
South Fork Winchuck River	2	1
Rowdy Creek	2	1
South Fork Rowdy	2	0
Dominie Creek	2	0
Wilson Creek	3	1
Hunter Creek	2	2
Turwar Creek	3	3
McGarvey Creek	2	0
Blue Creek	1	1
Potato Patch Creek	1	1
West Fork Blue Creek	2	1
Ah Pah Creek	0	2
Bear Creek	1	3
Tectah	0	2
Tully	0	1
Roach	0	1
Pecwan Creek	1	3
Coyote Creek	1	0
Lindsay Creek	1	1
North Fork Mad River	3	1
Long Prairie Creek	1	0
Dry Creek	1	0
Cañon Creek	3	1
Maple Creek	1	0
Boulder Creek	1	1
Jacoby Creek	2	0
Salmon Creek	2	1

### **C5.1.1.3 Results**

The 1994-95 monitoring effectively documented both diurnal (the difference between daily maximum and minimum temperatures) and seasonal temperature variations. Green Diamond calculated maximum weekly average temperatures (MWAT) for the 1994-1996 data as defined by the 1997 document Aquatic properly functioning condition matrix, a.k.a. the "Inter-Agency Matrix" (NMFS 1997). MWATs were generated by identifying the 7-day interval with the peak temperature and then calculating a mean temperature from all the data points recorded by the HOBO® device. For example, because Green Diamond has set their HOBO®s to record temperatures at 1.2 hour intervals (20 recordings for a 24-hour period), a MWAT would be the average of 140 data points for the hottest 7-day interval of the monitoring period. The MWAT for that creek was to be compared to established MWAT thresholds for a specific life stage and species. The MWAT threshold of 17.4°C for Coho summer rearing habitat was suggested in the "Inter-Agency Matrix" document. The temperature data indicated that on a Plan Area scale summer water temperatures were probably not limiting summer rearing habitat for salmonids. Of the 68 monitoring sites in 1994 and 95, 94% were below the suggested MWAT threshold of 17.4°C. The four sites that exceeded the MWAT of 17.4°C were all

large order streams with watersheds more than 15,000 acres upstream of the recorder. (See Tables C5-2 through C5-12 for a complete summary of Green Diamond's Class I and Class II summer temperature monitoring). Green Diamond believes that the single MWAT threshold value failed to account for natural variations in water temperature due to geographic location and drainage area of the monitored sub-basin. Also, depending on the method used to test the upper incipient lethal temperature of juvenile salmonids, a critical MWAT can range from 16.8°C to 18.4°C (Armour 1991; Thomas et al. 1986; Becker and Genoway 1979).

Following the 1994-5 temperature monitoring seasons improvements to the temperature monitoring protocol included collecting information relating to riparian canopy closure, channel morphology, flow and drainage area above the location of HOBOS. Temperature monitoring was continued annually in selected stream reaches, either those that exhibit excessive temperatures or those of special biological significance (extremely diverse or abundant salmonid populations). In 1995 Green Diamond conducted some experimental Class II temperature monitoring which was formalized and expanded in 1996.

### **C5.1.2 Water Temperature Monitoring Program (1996 to the Present)**

#### **C5.1.2.1 Objectives**

- Document the highest:
  - (a) 7DMAVG (highest 7-day moving average of all recorded temperatures),
  - (b) 7DMMX (highest 7-day moving average of the maximum daily temperatures),
  - (c) seasonal temperature fluctuations for each site for both Class I and Class II watercourses.
- Identify stream reaches with temperatures that have the potential to exceed the monitoring thresholds relative to the drainage area above the monitoring site for both Class I and Class II watercourses. (To account for the relationship between water temperature and drainage area, water temperature was regressed on the square root of watershed drainage area at locations known to support populations of southern torrent salamanders, tailed frogs or coho salmon throughout Green Diamond's ownership in the HPAs.
- Directly assess the effects of timber harvest on water temperatures in Class II watercourses (Before, After, Control, Impact [BACI] experiments).

One of the major changes in the monitoring protocols occurred in the analysis of the data. Initially the analysis of the MWAT was a manual search through the data file to find the seasonal peak and then it was assumed that the encompassing seven-day period would provide the highest average temperature. This process was automated in 1996 with an Excel Macro that actually calculated the average for every 7-day period and then selected the highest average as the critical metric.

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**Table C5-2. Summer water temperature monitoring summary, Smith River HPA.**

Stream Name	Site ID	Class	Year	Interval	7DMAVG	Mid Date (7DMAVG)	7DMMX	Mid Date (7DMMX)	Max	Max Date	Min after Max	Area (acres)
Goose (high)	13020101	1	1999	1:12	14.0	8/26	15.1	8/25	16.2	7/13	12.8	297.6
Goose (high)	13020101	1	2000	1:12	14.8	8/2	16.2	8/2	16.7	8/8	13.9	297.6
Wilson (low)	14010801	1	1994	0:48	12.2	7/4	13.7	7/4	13.9	6/27	11.4	7930.0
Goose (low)	14020201	1	1998	1:12	17.0	7/25	19.0	7/25	19.8	7/26	15.9	14752.0
Goose Low	14020201	1	1999	1:12	16.0	8/26	17.7	8/25	19.0	7/13	14.6	14752.0
Goose Trib	14020202	1	1998	1:12	15.4	7/25	16.8	7/24	17.8	7/26	14.6	4197.0
Goose Trib	14020202	1	1999	1:12	14.8	8/26	16.0	8/25	16.5	7/13	13.3	4197.0
Goose Mid	14022601	1	1999	1:12	14.8	8/26	15.8	8/25	16.1	8/25	14.1	663.6
Goose Mid	14022601	1	2000	1:12	15.5	8/2	16.8	8/2	17.3	8/1	14.7	663.6
Goose, East Fork	14022602	1	1999	1:12	13.2	8/26	13.7	8/25	13.9	8/25	12.6	1114.1
Goose, East Fork	14022602	1	2000	1:12	13.9	8/2	14.5	8/2	14.9	8/3	13.2	1114.1
Wilson Trib.	14510401	2	1996	1:12	12.1	8/30	12.5	8/30	12.7	8/30	11.9	679.1
Wilson (high)	15012901	1	1994	0:48	13.6	8/15	14.2	8/16	14.5	8/13	13.3	2146.0
Wilson (mid)	15013201	1	1994	0:48	13.4	8/16	14.0	8/16	14.2	8/13	13.1	3961.0
Wilson (mid)	15013201	1	1995	0:48	13.8	8/4	14.5	7/30	14.8	7/31	13.3	3961.0
Wilson (mid)	15013201	1	1996	1:12	13.8	8/30	16.1	8/30	16.5	8/30	12.9	3961.0
Wilson (mid)	15013201	1	1997	1:12	14.3	9/3	15.3	9/2	15.4	8/27	13.7	3961.0
Wilson (mid)	15013201	1	1998	0:08	13.8	8/15	14.4	8/13	14.8	7/26	13.4	3961.0
Wilson (mid)	15013201	1	1999	1:12	13.7	8/27	14.1	8/27	14.2	8/26	13.6	3961.0
Wilson (mid)	15013201	1	2000	1:12	13.7	9/22	14.5	7/31	14.6	7/29	13.3	3961.0
Goose (really low)	15023501	1	1997	1:12	17.3	8/9	19.6	8/9	20.6	8/7	16.1	22067.7
Little Mill	17010701	1	1998	1:12	13.5	8/13	14.2	8/13	14.7	7/26	13.0	2274.0
Little Mill	17010701	1	1999	1:12	13.5	8/27	14.0	8/25	14.2	8/26	13.6	2274.0
Sultan	17011901	1	1997	1:12	15.2	8/5	16.9	8/7	17.7	8/7	13.6	1281.0
Sultan	17011901	1	1999	1:12	13.7	8/26	14.2	8/25	14.5	8/26	13.7	1281.0
Peacock	17012901	1	1998	1:12	13.2	9/15	14.0	8/13	14.5	7/26	12.7	846.0
Peacock	17012901	1	2000	1:12	14.0	9/16	14.6	9/16	14.5	6/28	12.6	846.0
Campsix	17512501	1	1998	1:12	13.2	8/13	13.5	8/13	13.8	8/12	13.0	233.0
Campsix	17512501	1	1999	1:12	13.3	8/27	13.5	8/27	13.7	8/26	13.3	233.0
SF Winchuck Trib #1	18010601	2	1995	1:12	13.4	8/2	14.3	8/2	14.6	7/31	13.1	13.7
SF Winchuck Trib #2	18010602	2	1995	1:12	13.2	8/3	13.6	8/2	13.9	7/31	13.3	24.6
Rowdy trib R1700	18010901	2	1999	1:12	13.5	8/25	13.8	8/25	14.2	8/27	13.3	124.2
Rowdy trib R1700	18010901	2	2000	1:12	13.1	6/27	13.7	6/26	14.3	6/27	13.3	124.2

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**Table C5-2 Continued. Summer water temperature monitoring summary, Smith River HPA.**

Stream Name	Site ID	Class	Year	Interval	7DMAVG	Mid Date (7DMAVG)	7DMMX	Mid Date (7DMMX)	Max	Max Date	Min after Max	Area (acres)
Rowdy (high)	18011601	1	1994	1:12	14.8	8/15	16.3	8/15	16.5	7/14	13.1	7667.0
Rowdy (high)	18011601	1	1999	1:12	14.9	8/26	15.8	7/12	16.6	7/12	13.3	7667.0
Rowdy (high)	18011601	1	2000	1:12	15.6	9/19	16.9	9/19	17.8	9/19	15.8	7667.0
Ravine	18011701	1	1998	0:08	13.6	9/15	14.3	9/3	15.0	9/13	13.8	803.0
Ravine	18011701	1	2000	1:12	14.3	9/19	14.8	9/19	15.6	9/19	14.8	803.0
Rowdy trib. #3	18011801	2	1995	1:12	12.9	8/2	13.2	8/2	13.6	7/31	13.1	72.5
Rowdy trib. #4	18011901	2	1995	1:12	14.6	9/21	17.6	9/21	19.8	9/20	13.4	260.4
Rowdy Trib	18012001	2	1996	1:12	12.7	8/31	13.3	8/31	13.4	8/30	12.0	296.5
Rowdy (low)	18013001	1	1994	1:12	16.4	8/14	19.0	8/15	19.8	7/14	12.8	12587.0
Rowdy (low)	18013001	1	1995	1:12	16.6	8/3	19.3	8/3	19.4	8/19	13.7	12587.0
Rowdy (low)	18013001	1	1996	1:12	16.2	7/28	18.6	7/27	19.4	7/21	14.2	12587.0
Rowdy (low)	18013001	1	1997	1:12	16.5	8/5	19.1	8/5	19.9	8/7	14.8	12587.0
Rowdy (low)	18013001	1	1999	1:12	15.5	8/27	17.4	7/12	18.1	7/12	13.4	12587.0
Rowdy (low)	18013001	1	2000	1:12	15.6	7/31	17.4	7/30	18.3	8/2	14.3	12587.0
SF Rowdy (low)	18013002	1	1994	1:12	13.7	8/14	14.9	8/15	15.2	9/20	12.5	2573.0
SF Rowdy (low)	18013002	1	1997	1:12	14.3	8/27	15.6	8/5	16.1	8/7	13.3	2573.0
Savoy	18013003	1	1998	0:08	14.0	8/13	15.0	8/13	15.4	9/12	12.9	2573.0
Savoy	18013003	1	1999	1:12	13.7	8/27	14.4	8/25	14.6	8/22	13.1	2573.0
SF Rowdy (high)	18013004	1	1998	0:08	14.1	8/13	15.1	8/13	15.5	9/12	13.2	1552.0
SF Rowdy (high)	18013004	1	1999	1:12	13.7	8/27	14.4	8/24	14.6	7/12	12.1	1552.0
Savoy (high)	18013201	1	1994	1:12	13.1	8/16	13.8	8/15	14.0	8/16	12.5	2264.1
SF Winchuck River (high)	18510101	1	1994	1:12	13.2	8/16	13.8	8/15	14.3	9/21	12.5	1193.1
SF Winchuck River (high)	18510101	1	1999	1:12	13.4	8/25	13.8	8/25	14.4	7/12	12.9	1193.1
Gilbert	18510401	1	1997	1:12	14.6	9/3	15.5	9/2	15.9	9/5	13.9	1506.7
Gilbert	18510401	1	1999	1:12	13.2	8/27	13.8	8/24	14.1	8/21	12.7	1506.7
D2010CD	18511101	2	1996	1:12	12.2	10/9	12.5	10/8	13.1	10/8	12.5	10.5
D2010 CD	18511101	2	1997	1:12	12.3	8/7	12.8	8/7	13.7	8/7	12.8	10.5
D2010 CD	18511101	2	1998	1:12	12.6	9/3	13.1	9/3	13.9	9/3	12.9	10.5
D2010 CD	18511101	2	1999	1:12	12.1	8/25	12.5	8/25	13.4	7/12	11.2	10.5
D2010 CD	18511101	2	2000	1:12	10.9	9/19	11.0	9/19	11.2	9/19	10.9	10.5
D2010CU	18511102	2	1996	1:12	10.9	10/10	10.9	10/7	11.1	9/14	10.8	1.6

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**Table C5-2 Continued. Summer water temperature monitoring summary, Smith River HPA.**

Stream Name	Site ID	Class	Year	Interval	7DMAVG	Mid Date (7DMAVG)	7DMMX	Mid Date (7DMMX)	Max	Max Date	Min after Max	Area (acres)
D2010 CU	18511102	2	1997	1:12	11.0	9/14	11.2	9/14	11.4	8/7	11.1	1.6
D2010 CU	18511102	2	1998	1:12	11.9	9/11	12.1	9/11	12.0	9/2	11.9	1.6
D2010 CU	18511102	2	1999	1:12	10.6	8/27	10.7	9/10	10.8	8/26	10.8	1.6
D2010TD	18511103	2	1996	1:12	12.4	10/8	12.7	10/8	13.7	10/8	12.2	37.3
D2010 TD	18511103	2	1997	1:12	13.1	8/6	13.8	8/6	15.2	8/7	13.4	37.3
D2010 TD	18511103	2	1998	1:12	13.4	9/3	14.0	9/3	14.8	9/3	13.7	37.3
D2010 TD	18511103	2	1999	1:12	12.6	8/25	12.9	8/25	13.7	7/12	12.0	37.3
D2010 TD	18511103	2	2000	1:12	13.3	9/18	13.7	9/18	14.5	9/19	14.0	37.3
D2010TU	18511104	2	1996	1:12	11.6	10/10	11.7	10/10	12.0	10/8	12.0	7.3
D2010 TU	18511104	2	1997	1:12	11.6	9/28	11.7	8/8	12.0	8/7	12.0	7.3
D2010 TU	18511104	2	1998	1:12	12.2	9/4	12.4	9/4	12.8	9/3	12.5	7.3
D2010 TU	18511104	2	1999	1:12	11.2	8/26	11.3	8/25	11.7	8/27	11.2	7.3
D2010 TU	18511104	2	2000	1:12	11.9	9/19	12.1	9/19	12.5	9/19	12.3	7.3
D1120TD	18511105	2	1996	1:12	13.0	10/8	13.5	10/8	14.6	10/8	13.1	71.5
D1120 TD	18511105	2	1997	1:12	13.1	9/3	13.5	9/8	14.3	8/8	12.5	71.5
D1120 TD	18511105	2	1998	1:12	13.2	9/12	13.7	9/12	14.3	9/12	14.0	71.5
D1120 TD	18511105	2	1999	1:12	12.5	8/25	12.8	8/25	13.3	8/27	12.5	71.5
D1120 TD	18511105	2	2000	1:12	14.7	9/18	15.5	9/18	16.8	9/19	15.4	71.5
Dominie (high)	18511201	1	1994	1:12	11.9	9/19	12.1	7/10	12.5	9/20	12.0	394.5
D1120TU	18511202	2	1996	1:12	12.2	10/8	12.5	10/7	13.4	10/8	12.0	14.4
D1120 TU	18511202	2	1997	1:12	12.1	9/26	12.5	9/26	13.1	8/7	12.2	14.4
D1120 TU	18511202	2	1998	1:12	12.4	9/4	12.8	9/12	13.3	9/12	12.9	14.4
D1120 TU	18511202	2	1999	1:12	11.9	8/25	12.1	8/25	12.5	8/27	12.0	14.4
D1120 TU	18511202	2	2000	1:12	12.6	9/19	12.9	9/19	13.6	9/19	13.2	14.4
D1120CU	18511203	2	1996	1:12	13.0	10/8	13.4	10/8	14.6	10/8	13.1	17.7
D1120 CU	18511203	2	1997	1:12	12.7	9/8	13.1	8/6	14.0	8/7	13.4	17.7
D1120 CU	18511203	2	1998	1:12	13.4	9/4	13.8	9/12	14.3	9/3	13.9	17.7
D1120 CU	18511203	2	1999	1:12	12.7	8/25	13.1	8/25	13.7	8/26	13.3	17.7
D1120 CU	18511203	2	2000	1:12	14.0	9/18	14.5	9/19	15.6	9/19	14.8	17.7
D1120CD	18511204	2	1996	1:12	12.5	10/10	12.9	8/31	13.7	10/8	12.5	33.7
D1120 CD	18511204	2	1997	1:12	12.9	9/3	13.2	9/3	13.7	8/7	13.1	33.7
D1120 CD	18511204	2	1998	1:12	13.1	9/12	13.7	9/12	14.5	9/12	13.7	33.7
D1120 CD	18511204	2	1999	1:12	12.3	8/25	12.7	8/25	13.1	8/27	12.2	33.7
D1120 CD	18511204	2	2000	1:12	14.1	9/19	14.7	9/19	15.9	9/20	13.2	33.7
Dom Trib. #1	18511401	2	1995	1:12	13.3	7/30	14.0	8/1	14.6	7/31	13.1	40.8
Dom Trib. #2	18511402	2	1995	1:12	14.4	8/2	18.5	8/3	20.7	7/31	12.8	15.2
Dom Trib. #3	18511403	2	1995	1:12	13.9	9/22	14.8	9/21	16.9	9/19	14.8	38.7



GREEN DIAMOND AHCP/CCAA

**Table C5-2 Continued. Summer water temperature monitoring summary, Smith River HPA.**

Stream Name	Site ID	Class	Year	Interval	7DMAVG	Mid Date (7DMAVG)	7DMMX	Mid Date (7DMMX)	Max	Max Date	Min after Max	Area (acres)
Dom Trib. #4	18511404	2	1995	1:12	13.7	8/1	14.5	8/1	15.8	7/31	13.7	4.7
Dominie trib	18511405	2	1996	1:12	13.3	8/31	14.0	8/31	14.3	8/30	12.5	347.9
Dominie (low)	18512301	1	1994	1:12	14.3	8/15	16.0	8/16	16.2	8/13	13.1	2254.0
Dominie (low)	18512301	1	1997	1:12	14.7	9/3	15.8	9/3	16.4	9/5	13.6	2254.0
Dominie (low)	18512301	1	1998	0:08	14.2	8/13	15.4	8/13	15.7	7/26	13.3	2254.0
SF Winchuck River (low)	19513301	1	1994	1:12	14.5	8/15	16.0	8/16	16.5	8/31	12.2	5891.0
SF Winchuck River (low)	19513301	1	1995	1:12	14.7	8/3	16.1	8/3	16.9	8/19	13.4	5891.0
SF Winchuck River (low)	19513301	1	1996	1:12	14.8	8/31	16.5	8/30	17.5	9/1	13.4	5891.0
SF Winchuck River (low)	19513301	1	1997	1:12	15.5	9/3	16.9	8/5	17.7	8/7	14.5	5891.0
SF Winchuck River (low)	19513301	1	1998	0:08	14.7	8/14	16.6	9/14	18.4	9/11	12.2	5891.0
SF Winchuck River (low)	19513301	1	1999	1:12	14.1	8/16	15.1	8/23	15.8	6/22	12.5	5891.0
SF Winchuck River (low)	19513301	1	2000	1:12	15.3	9/18	16.5	9/18	17.8	9/20	14.1	5891.0

GREEN DIAMOND AHCP/CCAA

**Table C5-3. Summer water temperature monitoring summary, Coastal Klamath HPA.**

Stream Name	Site ID	Class	Year	Interval	7DMAVG	Mid Date (7DMAVG)	7DMMX	Mid Date (7DMMX)	Max	Max Date	Min after Max	Area (acres)
Little Surpur	11020201	1	1996	1:12	15.3	7/28	16.2	7/28	16.4	7/30	14.6	1601.0
Little Surpur	11020201	1	1998	1:12	14.8	7/25	15.3	7/24	15.8	7/26	14.6	1601.0
Little Surpur	11020201	1	1999	1:12	15.1	8/26	16.2	8/26	16.8	9/11	12.2	1601.0
Surpur	11020301	1	1996	0:30	14.6	7/28	15.8	7/28	16.1	7/30	13.9	3236.6
Surpur	11020301	1	1997	1:12	14.4	9/2	15.6	8/6	16.1	8/8	14.0	3236.6
Surpur	11020301	1	1999	1:12	14.0	8/26	14.7	8/25	14.9	8/24	12.8	3236.6
Tectah (old)	11021201	1	1995	0:48	16.2	8/4	18.2	8/3	18.6	8/4	15.1	11413.0
Tectah (low)	11021202	1	1995	1:12	16.3	8/4	18.5	8/3	19.1	8/4	15.2	11413.0
Tectah (low)	11021202	1	1997	1:12	16.3	8/16	16.6	8/15	16.7	8/8	15.9	11413.0
Tectah (low)	11021202	1	1998	1:12	16.9	7/25	18.7	7/25	19.4	7/26	16.1	11413.0
Tectah (low)	11021202	1	1999	1:12	16.2	8/26	17.4	7/11	18.1	7/12	14.6	11413.0
Tectah (low)	11021202	1	2000	1:12	17.3	8/4	18.8	8/1	19.5	6/28	15.4	11413.0
Tectah Trib. (class II)	11021301	2	1996	1:12	13.1	8/26	13.4	8/25	13.9	8/24	13.1	189.5
Tectah (mid)	11023401	1	1995	0:48	15.1	8/4	16.5	8/3	17.0	8/4	14.8	6892.5
Tectah (mid)	11023401	1	1997	1:00	15.6	8/6	17.1	8/6	17.9	8/8	14.9	6892.5
Tectah (mid)	11023401	1	1999	1:00	15.4	8/26	16.5	8/25	16.7	7/13	13.9	6892.5
McGarvey (high)	12010201	1	1994	0:48	12.8	8/17	13.3	8/16	13.4	8/13	12.8	1337.4
NF Ah Pah Trib. (161_up)	12020901	2	1996	1:12	13.3	7/29	13.6	7/28	13.9	7/30	13.1	616.7
NF Ah Pah Trib. (161_up)	12020901	2	1997	1:12	13.4	9/3	13.5	9/1	13.6	8/7	13.3	616.7
Ah Pah (North Fork)	12021601	1	1995	1:12	14.8	8/4	15.8	8/3	16.2	8/4	14.3	670.0
Ah Pah (North Fork)	12021602	1	1996	0:30	15.0	7/28	16.1	7/28	16.4	7/30	14.1	670.0
Ah Pah (North Fork)	12021602	1	1997	0:30	14.7	8/6	15.5	8/6	16.1	8/8	14.2	670.0
NF Ah Pah Trib. (161_lo)	12021603	2	1996	1:12	13.9	7/28	14.5	7/28	14.8	7/30	13.3	669.7
NF Ah Pah Trib. (161_lo)	12021603	2	1997	1:12	14.0	9/3	14.5	8/6	14.8	8/7	13.7	669.7
Ah Pah (South Fork)	12022101	1	1995	1:12	14.2	8/4	15.5	8/2	15.9	8/4	13.4	1501.0
Ah Pah (South Fork)	12022101	1	1996	0:30	14.0	7/30	14.8	7/28	14.9	7/29	13.8	1501.0
Ah Pah (South Fork)	12022101	1	1997	0:30	14.0	9/4	14.2	9/4	14.2	8/7	13.7	1501.0
Ah Pah (South Fork)	12022101	1	1999	1:00	13.4	8/27	13.7	8/27	13.8	8/28	13.5	1501.0
Ah Pah (Middle Fork)	12022103	1	1996	0:30	15.2	7/31	15.6	8/25	15.4	7/29	15.0	3068.0
Ah Pah (Middle Fork)	12022103	1	1997	0:30	15.9	8/6	18.3	8/6	18.7	8/7	14.9	3068.0

GREEN DIAMOND AHCP/CCAA

**Table C5-3 Continued. Summer water temperature monitoring summary, Coastal Klamath HPA.**

Stream Name	Site ID	Class	Year	Interval	7DMAVG	Mid Date (7DMAVG)	7DMMX	Mid Date (7DMMX)	Max	Max Date	Min after Max	Area (acres)
Bear Creek Trib	12022401	2	1996	1:12	13.4	8/18	13.7	8/18	14.1	8/24	13.1	435.2
Bear (Klamath)	12022501	1	1995	0:48	14.1	8/4	14.9	8/3	15.1	8/4	13.9	2659.0
Bear (Klamath)	12022601	1	1994	0:48	13.7	8/17	14.4	8/16	14.5	8/13	13.3	5343.0
Bear (Klamath)	12022601	1	1995	0:48	14.4	8/4	15.2	8/3	15.4	8/4	13.9	5343.0
Bear (Klamath)	12022601	1	1996	0:30	14.9	7/28	16.0	7/28	16.2	7/29	14.2	5343.0
Bear (Klamath)	12022601	1	1996	1:12	14.9	7/28	15.9	7/28	16.2	7/30	14.2	5343.0
Bear (Klamath)	12022601	1	1997	0:30	14.8	8/9	15.7	8/6	16.0	8/8	14.3	5343.0
Bear (Klamath)	12022601	1	1999	1:00	14.1	8/26	14.8	8/25	15.0	8/26	14.0	5343.0
Bear, South Fork(Klamath)	12033101	1	1995	0:48	13.2	8/4	13.7	8/3	14.0	8/4	13.1	1216.5
Hunter	13010402	1	1995	0:30	12.2	6/23	13.6	6/22	14.2	6/20	11.2	13710.7
Hunter	13010402	1	1999	0:30	12.2	7/14	13.9	7/14	14.3	6/22	10.9	13710.7
McGarvey (low)	13012401	1	1994	0:48	13.4	7/20	14.3	7/19	14.5	7/7	12.8	4808.0
McGarvey (low)	13012501	1	1996	0:30	14.6	7/28	15.7	7/27	15.9	7/29	14.0	4808.0
McGarvey (low)	13012501	1	1999	0:30	15.0	8/26	16.4	8/25	16.8	8/25	14.6	4808.0
Turwar (low)	13020501	1	1994	0:48	17.6	8/16	19.7	8/16	19.9	8/14	16.1	16746.0
Turwar (low)	13020501	1	1995	0:48	16.9	8/4	18.7	8/2	19.1	7/16	15.1	16746.0
Turwar (low)	13020501	1	1996	1:12	17.2	7/28	18.9	7/27	19.3	7/29	15.8	16746.0
Turwar (low)	13020501	1	1997	1:12	17.4	8/6	19.1	8/5	19.6	8/7	16.2	16746.0
Turwar (low)	13020501	1	1998	1:12	17.0	8/15	18.4	8/13	19.0	7/26	15.8	16746.0
Turwar (low)	13020501	1	1999	1:12	16.6	8/25	18.6	7/12	19.1	7/13	14.8	16746.0
Turwar (low)	13020501	1	2000	1:12	17.2	8/1	19.3	8/1	19.7	8/1	16.0	16746.0
Tarup	13022901	1	1996	0:30	13.6	7/28	14.2	7/28	14.3	7/29	13.4	3098.0
Omagaar	13023201	1	1996	0:30	13.5	7/28	14.0	7/28	14.2	7/29	13.1	857.2
Hunter (mid)	14010201	1	1994	0:48	13.5	8/16	14.2	8/16	14.3	8/13	13.3	3197.6
Hunter (mid)	14010201	1	1999	1:00	14.3	8/27	14.9	8/27	15.1	8/22	13.8	3197.6
Hunter (mid)	14010201	1	1999	1:12	14.1	8/27	14.5	8/25	14.6	8/22	13.7	3197.6
Kurowitz	14010202	1	1999	1:12	14.5	8/26	15.3	7/12	15.9	7/12	12.9	864.9
Kurowitz	14010202	1	2000	1:12	15.2	9/19	16.4	7/31	17.0	9/19	15.3	864.9
Hunter Trib.	14011101	2	1996	1:12	13.1	8/30	15.5	8/31	15.9	9/1	11.4	608.2
Hunter (low)	14011102	1	1995	0:48	14.9	8/4	17.0	8/2	17.2	7/31	13.6	5701.0
Hunter (low)	14011102	1	1996	1:12	14.9	7/28	16.8	7/28	17.0	7/29	13.9	5701.0
Hunter (low)	14011102	1	1997	1:12	15.3	8/6	17.6	8/5	18.0	8/7	14.2	5701.0
Hunter (low)	14011102	1	1998	0:08	15.2	8/14	17.0	8/13	17.5	7/26	14.2	5701.0
Hunter (low)	14011102	1	2000	1:12	15.6	7/31	18.2	7/31	18.5	8/1	14.4	5701.0
Mynot	14013501	1	1999	1:12	13.4	8/26	14.0	8/22	14.3	6/22	11.4	516.7
Turwar (high)	14020601	1	1994	0:48	13.2	7/31	13.7	7/31	13.7	7/31	12.8	1317.0
Turwar (high)	14020601	1	1995	0:48	14.4	8/4	14.9	8/3	15.4	8/4	14.6	1317.0

GREEN DIAMOND AHCP/CCAA

**Table C5-3 Continued. Summer water temperature monitoring summary, Coastal Klamath HPA.**

Stream Name	Site ID	Class	Year	Interval	7DMAVG	Mid Date (7DMAVG)	7DMMX	Mid Date (7DMMX)	Max	Max Date	Min after Max	Area (acres)
Turwar Trib. (class II)	14020602	2	1996	1:12	14.3	8/14	14.8	8/14	14.9	8/15	14.0	369.1
Turwar (mid)	14022101	1	1994	0:48	17.0	8/15	19.2	7/16	19.6	7/18	15.0	7606.0
Turwar (mid)	14022101	1	1995	0:48	16.8	8/4	19.1	8/3	19.4	8/4	15.6	7606.0
Turwar	14022102	1	1997	1:00	16.4	8/6	17.9	7/21	18.7	7/19	15.0	8238.0
Turwar	14022102	1	1999	1:00	16.2	8/25	17.9	8/23	18.6	7/12	14.4	8238.0
SF Turwar	14022901	1	2000	1:12	14.4	9/19	15.2	9/19	16.3	9/19	13.9	5091.2
Hunter (high)	15013501	1	1994	0:48	14.0	8/16	14.7	8/16	14.8	7/18	12.6	2163.2
Hunter (high)	15013501	1	1995	0:48	14.3	8/7	15.5	8/7	15.8	8/7	13.1	2163.2

GREEN DIAMOND AHCP/CCAA

**Table C5-4. Summer water temperature monitoring summary, Blue Creek HPA.**

Stream Name	Site ID	Class	Year	Interval	7DMAVG	Mid Date (7DMAVG)	7DMMX	Mid Date (7DMMX)	Max	Max Date	Min after Max	Area (acres)
Blue (West Fork)	12020101	1	1994	0:48	14.2	8/16	15.8	8/16	15.9	8/13	13.4	8616.0
Blue (West Fork)	12020101	1	1996	1:12	15.3	7/28	16.8	7/28	17.0	7/30	14.5	8616.0
Blue (West Fork)	12020101	1	1997	1:00	15.2	8/6	16.9	8/6	17.3	8/7	14.5	8616.0
Blue (West Fork)	12020101	1	1999	1:00	15.1	8/26	16.5	8/23	16.8	8/22	14.3	8616.0
Blue	12021101	1	1994	0:48	17.2	8/15	19.8	7/16	20.2	7/18	14.8	78520.0
Blue	12021101	1	1995	0:48	17.3	8/4	19.9	8/3	20.6	8/4	15.6	78520.0
Blue	12021101	1	1997	0:30	18.0	8/6	20.9	8/6	21.4	8/7	16.1	78520.0
Blue	12021101	1	1999	0:30	17.1	8/23	19.5	8/23	20.1	8/22	15.6	78520.0
Slide	12021401	1	1997	1:00	14.3	8/6	16.1	8/6	16.4	8/7	13.6	78520.0
Slide	12021401	1	1999	1:00	13.5	8/25	15.4	7/12	16.0	7/12	12.4	78520.0
Nickowitz	12030301	1	1996	0:30	14.4	7/28	15.3	7/28	15.5	7/30	13.6	9693.0
Nickowitz	12030301	1	1997	1:00	14.2	8/7	15.2	8/6	15.7	8/8	13.8	9693.0
Nickowitz	12030301	1	1999	1:00	13.7	8/26	14.4	8/25	14.7	7/13	12.7	9693.0
Coyote (Blue Cr.)	12031701	2	1996	1:12	11.5	8/26	12.0	8/25	12.8	8/24	11.3	435.2
Dandy	13020801	1	2000	1:12	13.3	9/16	13.8	9/16	13.7	9/13	12.9	1244.3
Blue (West Fork)	13022301	1	1994	0:48	12.9	7/19	13.5	7/19	13.7	7/17	12.3	1389.0
Potato Patch (185_up)	13022501	2	1996	1:12	14.1	7/28	15.6	7/28	15.8	7/25	13.1	482.5
Potato Patch (185_up)	13022501	2	1997	1:12	15.1	8/10	16.7	8/9	17.3	8/8	14.6	482.5
Potato Patch	13023601	1	1994	0:48	14.0	8/11	14.5	8/10	14.6	8/9	13.9	1782.0
Potato Patch	13023601	1	2000	1:12	14.5	9/20	14.9	9/19	15.6	9/20	14.3	1782.0
Blue	13033401	1	1996	0:30	17.1	7/28	18.7	7/28	19.0	7/30	15.5	31753.1
Blue	13033401	1	1997	1:00	16.7	8/9	18.2	8/6	18.7	8/8	15.7	31753.1
Blue	13033401	1	1999	1:00	15.5	8/26	16.5	8/25	17.2	7/13	13.8	31753.1
Crescent City Fork	13033402	1	1996	0:30	15.2	7/28	16.5	7/28	16.6	7/28	14.1	14343.1
Crescent City Fork	13033402	1	1997	1:00	14.7	8/9	15.9	8/6	16.5	8/8	14.2	14343.1
Crescent City Fork	13033402	1	1999	1:00	14.2	8/26	15.0	8/25	15.8	7/13	13.0	14343.1
Potato Patch (185_lo)	13033801	2	1996	1:12	15.4	7/28	16.0	7/28	16.2	7/28	15.0	1079.0
Potato Patch (185_lo)	13033801	2	1997	1:12	15.3	8/10	16.0	8/9	16.7	8/8	15.1	1079.0

GREEN DIAMOND AHCP/CCAA

**Table C5-5. Summer water temperature monitoring summary, Interior Klamath HPA.**

Stream Name	Site ID	Class	Year	Interval	7DMAVG	Mid Date (7DMAVG)	7DMMX	Mid Date (7DMMX)	Max	Max Date	Min after Max	Area (acres)
Tully (high)	09030301	1	1999	1:12	14.5	8/26	15.4	8/26	16.2	7/13	13.4	1096.2
Tully	09030301	1	2000	1:12	14.9	8/3	16.1	8/3	16.4	8/2	14.2	1096.2
Pine	09040501	1	1999	1:00	17.4	8/26	18.2	8/25	19.3	7/13	16.3	31200.7
Mettah (high)	10021001	1	1999	1:12	14.0	8/26	14.6	8/26	14.8	8/28	13.9	362.6
Mettah (high)	10021001	1	2000	1:12	14.1	8/5	15.0	8/4	15.3	8/3	13.7	362.6
Roach (upper)	10022501	2	1997	1:12	16.4	8/9	18.6	8/6	19.6	8/8	15.3	10808.1
Cappell	10030301	1	1996	0:30	16.4	7/28	17.3	7/28	17.5	7/28	15.3	5253.1
Roach	10030801	1	1995	0:48	18.2	7/22	20.3	7/22	21.5	7/24	17.8	18613.0
Roach	10030801	1	1996	0:30	20.1	7/28	22.1	7/28	22.4	7/27	19.1	18613.0
Morek	10030901	1	1996	1:12	14.7	7/28	15.5	7/28	15.6	7/26	14.3	2561.9
Waukell (past Tectah)	10032301	2	1996	1:12	12.9	8/13	13.2	8/13	13.4	8/13	12.5	153.9
Tully (low)	10032501	1	1995	0:48	16.1	8/4	17.1	8/4	18.0	8/5	15.3	11085.0
Tully (low)	10032501	1	1997	1:00	16.6	8/9	17.8	8/9	18.5	8/8	16.2	11085.0
Johnson (188_lo)	11022401	2	1996	1:12	13.7	7/28	14.1	7/28	14.2	7/26	13.4	907.7
Johnson (188_lo)	11022401	2	1997	1:12	13.2	8/8	13.7	8/7	14.2	8/8	13.3	907.7
Johnson (188_up)	11022402	2	1996	1:12	13.3	7/28	13.7	7/28	13.9	7/30	12.8	770.9
Johnson (188_up)	11022402	2	1997	1:12	12.8	8/7	13.2	8/7	13.9	8/8	12.9	770.9
Johnson	11022403	1	1997	1:12	13.2	8/27	13.3	8/24	13.4	9/17	13.1	1940.5
Mettah (low)	11023601	1	1996	1:12	16.1	7/28	17.2	7/28	17.3	7/27	15.6	6180.5
Clirliah Trib	11023602	2	1996	1:12	13.6	8/26	13.9	8/25	14.2	8/24	13.6	259.5
Pecwan, West Fork	11030901	1	1995	0:48	12.9	8/4	13.4	8/3	14.2	8/4	13.3	7473.8
Pecwan, West Fork	11030901	1	1999	1:12	12.5	8/26	12.8	8/26	13.1	8/26	12.6	7473.8
Pecwan, West Fork	11030901	1	2000	1:12	12.4	8/3	12.8	6/26	13.3	8/2	12.3	7473.8
Pecwan, East Fork	11031501	1	1995	0:48	12.7	8/4	13.2	8/3	14.2	8/4	12.9	6585.0
Pecwan, East Fork	11031501	1	1999	1:12	12.7	8/26	13.0	8/26	13.4	8/26	12.9	6585.0
Pecwan, East Fork	11031501	1	2000	1:12	12.6	8/4	13.1	6/26	13.6	6/28	12.3	6585.0
Pecwan	11031701	1	1994	0:48	14.1	7/20	15.0	7/19	15.3	7/17	13.3	17594.0
Pecwan	11031701	1	1995	0:48	14.4	8/7	15.6	8/7	17.8	8/4	14.6	17594.0
Pecwan	11031701	1	1996	0:30	15.7	7/28	17.0	7/28	17.3	7/30	14.8	17594.0
Pecwan	11031701	1	1999	1:00	14.7	8/26	16.0	8/26	16.3	8/26	14.4	17594.0

GREEN DIAMOND AHCP/CCAA

**Table C5-6. Summer water temperature monitoring summary, Redwood Creek HPA.**

Stream Name	Site ID	Class	Year	Interval	7DMAVG	Mid Date (7DMAVG)	7DMMX	Mid Date (7DMMX)	Max	Max Date	Min after Max	Area (acres)
Lake Prairie	05041901	2	1997	2:24	15.4	8/9	17.5	8/9	18.5	8/7	14.6	973.5
Lake Prairie	05041901	2	1998	2:30	15.6	7/21	17.1	7/21	17.8	7/21	14.9	973.5
Lake Prairie	05041901	2	1999	1:12	14.4	8/26	15.9	7/12	17.1	7/13	13.6	973.5
Lake Prairie	05041901	2	2000	0:36	15.1	8/2	16.4	6/26	17.0	6/28	13.5	973.5
Redwood at Miñon	05042001	1	2000	1:12	17.7	8/5	20.6	8/5	20.9	8/3	15.9	18416.6
Pardee	05043201	2	1996	2:24	14.4	7/28	15.0	7/27	15.2	7/27	14.3	1579.0
Pardee	05043201	1	1997	2:24	13.6	8/10	14.1	8/10	14.8	8/8	13.3	1579.0
Pardee	05043201	2	1998	2:30	14.1	7/21	14.7	7/22	15.2	7/22	14.3	1579.0
Pardee	05043201	2	1999	1:12	13.2	8/26	13.6	8/26	14.3	7/13	12.3	1579.0
Pardee	05043201	1	2000	0:36	9.9	5/24	10.7	5/23	11.3	5/21	8.9	1579.0
Lupton	06031501	1	1997	1:12	14.9	8/10	15.9	8/10	16.7	8/8	14.5	2862.0
Lupton	06031501	1	1998	1:12	15.2	9/4	16.0	9/4	16.5	7/26	14.5	2862.0
Lord Ellis	07033301	2	1996	1:12	12.7	8/26	12.9	8/26	13.3	8/24	12.8	371.7
Coyote ( Rdwd)	08020201	1	1994	1:12	16.0	8/16	16.9	8/14	17.4	8/13	15.5	5025.0
Coyote ( Rdwd)	08020201	1	1999	1:12	17.1	8/26	18.5	7/12	19.7	7/12	15.9	5025.0
Coyote ( Rdwd)	08020201	1	2000	1:12	17.8	8/1	19.2	8/1	19.9	6/28	16.1	5025.0
Redwood at Panther	08021301	1	1999	1:12	20.9	7/13	22.9	7/12	24.0	7/12	19.8	15688.1
Redwood at Panther	08021301	1	2000	1:12	22.0	8/1	23.9	8/1	24.7	6/27	19.6	15688.1
Panther (Rdwd)	08021401	1	1998	0:08	14.6	9/4	15.3	7/25	15.9	7/26	14.4	3814.0
Panther (Rdwd)	08021401	1	1999	1:12	14.5	8/26	14.9	8/26	15.0	8/24	13.8	3814.0
Panther (Rdwd)	08021401	1	2000	1:12	14.4	8/4	15.1	8/2	15.4	8/2	14.0	3814.0
Panther (Rdwd)	08021402	1	1994	2:00	13.1	7/22	13.5	7/20	13.6	7/17	12.2	3814.0
Panther (Rdwd)	08021402	1	1995	2:00	14.2	8/4	14.8	8/4	15.2	8/5	13.6	3814.0
Panther Rhva 2	08021601	2	2000	1:12	12.7	9/20	13.0	9/20	13.7	9/20	12.3	58.1
Panther Rhva 3	08022102	2	2000	1:12	12.8	9/20	13.1	9/20	13.8	9/20	12.7	75.5
Panther O-6	08022201	2	1999	1:12	13.6	8/26	13.8	8/26	14.1	8/27	13.7	455.6
North Fork Dolly Varden	08023601	2	1996	2:24	14.5	7/28	14.9	7/28	15.2	7/30	14.0	1069.0
North Fork Dolly Varden	08023601	2	1996	2:24	12.5	10/10	12.7	10/8	13.1	10/8	12.2	1069.0
North Fork Dolly Varden	08023601	2	1997	2:24	13.9	7/27	14.3	7/26	14.6	7/28	13.7	1069.0
North Fork Dolly Varden	08023601	2	1997	2:24	14.4	8/12	14.7	8/12	14.8	8/13	14.0	1069.0
North Fork Dolly Varden	08023601	2	1998	2:30	14.7	8/30	15.1	8/30	15.2	7/22	14.6	1069.0
North Fork Dolly Varden	08023601	2	1999	1:12	13.9	8/26	14.1	8/26	14.3	7/13	13.1	1069.0
South Fork Dolly Varden	08023602	2	1996	2:24	14.8	7/28	15.2	7/28	15.5	7/29	14.6	597.2
South Fork Dolly Varden	08023602	2	1998	2:30	14.7	8/30	15.1	8/30	15.5	7/23	13.7	597.2
South Fork Dolly Varden	08023602	2	1999	1:12	13.9	8/26	14.2	8/26	14.5	7/12	13.6	597.2
South Fork Dolly Varden	08023602	2	2000	1:12	13.8	8/3	14.3	6/27	15.1	6/27	13.8	597.2
Coyote Trib (Redwood Cr.)	09033101	2	1996	1:12	14.4	8/26	15.1	8/25	16.1	8/24	14.2	879.1

GREEN DIAMOND AHCP/CCAA

**Table C5-7. Summer water temperature monitoring summary, Coastal Lagoons HPA.**

Stream Name	Site ID	Class	Year	Interval	7DMAVG	Mid Date (7DMAVG)	7DMMX	Mid Date (7DMMX)	Max	Max Date	Min after Max	Area (acres)
WindyTD	08010601	2	1999	1:12	11.8	8/27	11.9	8/26	12.1	8/27	11.9	34.3
WindyTD	08010601	2	2000	1:12	12.1	9/19	12.2	9/19	12.3	9/19	12.1	34.3
WindyCD	08010602	2	1999	1:12	11.7	8/27	11.9	8/27	12.0	8/27	11.9	45.6
WindyCD	08010602	2	2000	1:12	12.2	9/19	12.4	9/18	12.8	9/19	12.5	45.6
WindyTU	08010701	2	1999	1:12	10.6	8/27	10.6	8/27	10.8	8/27	10.6	26.9
WindyTU	08010701	2	2000	1:12	11.3	9/25	11.3	9/23	11.3	9/20	11.2	26.9
WindyCU	08010702	2	1999	1:12	11.9	8/27	12.0	8/27	12.2	8/27	12.0	33.7
WindyCU	08010702	2	2000	1:12	12.4	9/19	12.6	9/20	12.9	9/19	12.7	33.7
Maple (mid)	08010801	1	1994	2:00	15.0	8/19	15.8	8/19	16.1	8/21	14.3	1687.7
Maple (mid)	08010801	1	1996	2:00	14.9	7/28	15.5	7/27	15.8	7/29	14.2	1687.7
Maple (mid)	08010801	1	1999	1:12	15.3	8/26	15.8	8/26	16.1	8/29	14.2	1687.7
Maple (mid)	08010801	1	2000	1:12	15.3	7/31	15.9	7/31	16.5	6/27	14.5	1687.7
M-Line	08010802	1	1994	2:00	13.9	8/19	14.6	8/21	14.6	8/20	13.4	361.7
M-Line	08010802	1	1995	2:00	14.2	8/3	15.5	8/3	15.8	8/1	13.2	361.7
M-Line	08010802	1	1999	1:12	14.1	8/26	14.5	8/26	14.8	8/26	14.2	361.7
M-Line	08010802	1	2000	1:12	13.7	7/31	14.4	7/31	14.8	8/1	13.3	361.7
Maple (high)	08011201	1	1994	2:00	14.0	8/19	14.5	8/21	14.8	8/19	14.0	2639.2
Maple (high)	08011201	1	1995	2:00	14.9	8/4	15.8	8/3	16.2	8/1	14.1	2639.2
Maple (high)	08011201	1	1996	2:00	15.2	7/28	16.1	7/27	16.2	7/27	14.6	2639.2
Clear	08011202	1	1997	2:00	14.1	9/3	14.8	7/25	15.2	8/8	13.7	1864.2
Clear	08011202	1	2000	1:12	14.1	8/1	15.3	7/31	16.0	6/28	13.2	1864.2
Beach	08011501	1	1994	2:00	13.9	8/19	14.6	8/21	14.6	8/19	13.6	469.1
Beach	08011501	1	1995	2:00	14.3	8/4	14.7	8/3	14.9	8/1	14.0	469.1
Beach	08011501	1	1999	1:12	14.8	8/26	15.6	8/25	16.0	8/26	14.7	469.1
Beach	08011501	1	2000	1:12	14.8	8/1	15.6	7/31	15.9	8/1	14.3	469.1
Beach	08011501	1	2000	1:12	14.8	8/1	15.6	7/31	15.9	8/1	14.3	469.1
Luffenholtz	08012901	1	1996	2:00	12.8	7/28	13.3	7/28	13.8	7/29	12.1	1688.9
Luffenholtz	08012901	1	1997	2:00	13.5	9/3	14.0	9/3	14.4	8/27	12.6	1688.9
M1CU	08020701	2	1999	1:12	13.2	8/26	13.5	8/26	14.1	8/27	13.2	179.3
M1CU	08020701	2	2000	1:12	13.5	9/18	13.8	9/18	14.9	9/20	13.0	179.3
M1CD	08020702	2	1999	1:12	13.5	8/26	13.9	8/26	14.8	8/27	13.4	193.3
M1CD	08020702	2	2000	1:12	13.9	9/17	14.4	9/18	15.6	9/20	12.8	193.3
M1TU	08021701	2	1999	1:12	13.2	8/26	13.4	8/26	14.0	8/27	13.3	70.0
M1TU	08021701	2	2000	1:12	13.9	9/18	14.3	9/20	15.2	9/20	13.2	70.0
M1TD	08021702	2	1999	1:12	14.1	8/26	14.6	8/25	15.3	8/27	14.1	79.1
M1TD	08021702	2	2000	1:12	14.7	9/17	15.1	9/18	16.3	6/27	14.2	79.1
M1TU2	08021703	2	1999	1:12	13.6	8/26	13.9	8/26	14.6	8/27	13.6	59.4
M1TU2	08021703	2	2000	1:12	14.2	9/20	14.6	9/20	15.4	9/20	13.8	59.4
M1TD2	08021704	2	1999	1:12	14.0	8/26	14.4	8/26	15.2	8/27	14.1	65.4



GREEN DIAMOND AHCP/CCAA

**Table C5-7 Continued. Summer water temperature monitoring summary, Coastal Lagoons HPA.**

Stream Name	Site ID	Class	Year	Interval	7DMAVG	Mid Date (7DMAVG)	7DMMX	Mid Date (7DMMX)	Max	Max Date	Min after Max	Area (acres)
M1TD2	08021704	2	2000	1:12	14.7	9/17	15.3	9/18	16.5	9/20	13.4	65.4
Mill Cr. (LP)	08511301	1	1997	2:00	13.8	9/3	14.0	9/3	14.2	9/4	13.7	617.3
McDonald	09010501	1	1996	2:00	12.6	8/29	13.6	8/30	14.0	8/30	12.6	3346.4
McDonald	09010501	1	1997	2:00	14.9	9/3	15.7	9/3	16.0	8/24	14.4	3346.4
McDonald	09010501	1	2000	1:12	13.3	9/17	14.1	9/18	14.7	9/19	12.9	3346.4
Pitcher	09012001	1	1996	2:00	13.6	8/30	15.0	8/31	15.6	8/30	13.6	3358.4
Pitcher	09012001	1	1997	2:00	14.9	9/3	15.9	9/3	16.2	9/1	13.7	3358.4
Pitcher	09012001	1	1999	1:12	13.7	8/27	14.3	8/27	14.7	8/29	13.1	3358.4
Pitcher	09012001	1	2000	1:12	13.3	7/31	13.8	9/17	14.2	9/19	12.6	3358.4
NF Maple Trib Fline	09012701	2	1999	1:12	13.0	8/27	14.5	7/21	13.5	8/27	13.2	249.5
Maple,NF (lower)	09012901	1	1994	2:00	14.4	8/13	15.3	8/5	15.8	8/13	14.5	6467.0
Maple,NF (lower)	09012901	1	1995	2:00	14.9	7/29	16.2	7/29	16.7	7/27	14.2	6467.0
Maple,NF (lower)	09012901	1	1996	2:00	14.8	7/27	15.7	7/27	16.2	7/27	14.4	6467.0
Maple,NF (lower)	09012901	1	1998	1:12	15.0	8/14	15.8	8/14	16.2	7/19	14.3	6467.0
Maple,NF (lower)	09012901	1	1999	1:12	15.3	8/27	16.0	8/23	16.5	8/29	14.8	6467.0
Maple,NF (lower)	09012901	1	2000	1:12	15.1	7/31	15.8	7/31	16.2	8/1	14.6	6467.0
Maple (low)	09012902	1	1994	2:00	15.3	8/16	16.2	8/6	16.7	8/3	15.0	16797.0
Maple (low)	09012902	1	1996	2:00	15.4	7/27	17.0	7/12	17.4	7/13	14.1	16797.0
Maple (low)	09012902	1	1998	1:12	15.8	8/14	17.5	7/16	18.4	7/19	14.9	16797.0
Maple (low)	09012902	1	1999	1:12	16.1	8/24	18.4	8/23	19.1	8/21	14.5	16797.0
Maple (low)	09012902	1	2000	1:12	16.5	7/31	18.7	7/31	19.6	8/1	15.4	16797.0
Maple,NF (upper)	09013401	1	1996	2:00	13.2	7/31	13.3	7/31	13.4	7/29	13.2	3460.3
Maple,NF (upper)	09013401	1	1997	2:00	14.1	8/27	14.7	8/22	15.3	8/7	13.3	3460.3
NF Maple Trib F8	09013401	2	2000	1:12	13.5	9/17	13.8	9/17	14.5	9/19	13.3	273.0
McDonald, NF	10012901	1	1997	2:00	13.5	9/3	13.8	9/3	14.0	8/29	12.5	1273.5
McDonald, NF	10012901	1	2000	1:12	13.3	9/17	13.6	9/17	14.1	9/19	12.7	1273.5

GREEN DIAMOND AHCP/CCAA

**Table C5-8. Summer water temperature monitoring summary, Little River HPA.**

Stream Name	Site ID	Class	Year	Interval	7DMAVG	Mid Date (7DMAVG)	7DMMX	Mid Date (7DMMX)	Max	Max Date	Min after Max	Area (acres)
Freeman	07010301	1	2000	1:12	13.4	7/31	14.1	7/31	14.3	8/1	13.0	1083.0
Little River (low)	07010801	1	1994	2:00	16.8	8/5	18.8	8/5	19.3	8/3	16.2	26011.0
Little River (low)	07010801	1	1995	2:00	16.8	8/4	18.6	7/29	19.3	7/31	15.6	26011.0
Little River (low)	07010801	1	1996	2:00	17.4	7/28	19.4	7/31	20.1	7/28	16.6	26011.0
Little River (low)	07010801	1	1998	1:12	17.0	8/15	19.0	8/15	19.8	7/19	16.2	26011.0
Little River (low)	07010801	1	1999	1:12	16.9	8/23	18.7	7/14	19.6	8/21	16.4	26011.0
Little River (low)	07010801	1	2000	1:12	17.4	7/31	19.2	7/30	20.2	7/28	16.5	26011.0
Carson	07011001	1	1997	1:12	14.9	8/27	15.4	8/27	15.8	7/18	13.7	2440.0
Carson	07011002	1	1998	1:12	14.7	8/14	15.6	7/16	16.2	7/18	14.0	2440.0
Carson	07011002	1	1999	1:12	14.8	8/24	15.3	8/23	16.0	6/22	13.2	2440.0
Carson	07011002	1	2000	1:12	14.8	7/31	15.3	7/31	15.7	7/28	14.4	2440.0
M155CD	07011201	2	1999	1:12	12.4	8/27	12.5	8/27	12.6	8/27	12.5	44.1
M155CD	07011201	2	2000	1:12	12.3	8/2	12.4	8/1	12.6	8/1	12.4	44.1
M155CU	07011202	2	1999	1:12	13.2	8/27	13.5	8/27	13.7	8/26	13.4	34.5
M155CU	07011202	2	2000	1:12	13.9	9/18	14.5	9/18	15.7	9/19	13.8	34.5
MitsuiCU	07011301	2	1996	1:12	12.8	8/30	13.0	8/30	13.4	10/8	12.8	60.4
MitsuiCU	07011301	2	1997	1:12	14.1	9/3	14.2	9/3	14.3	8/26	14.0	60.4
MitsuiCU	07011301	2	1998	1:12	12.8	8/14	13.0	8/14	13.3	7/26	12.8	60.4
MitsuiCU	07011301	2	1999	1:12	12.9	8/26	13.1	8/26	13.3	8/26	12.8	60.4
MitsuiCU	07011301	2	2000	1:12	13.2	9/18	13.5	9/18	14.1	9/19	13.3	60.4
MitsuiCD	07011401	1	1996	1:12	12.4	7/30	12.6	8/30	12.8	7/30	12.2	97.9
MitsuiCD	07011401	1	1997	1:12	13.7	9/3	14.4	9/3	14.6	9/4	13.7	97.9
MitsuiCD	07011401	1	1998	1:12	12.8	8/15	13.0	8/14	13.1	8/15	12.6	97.9
MitsuiCD	07011401	1	1999	1:12	13.1	8/27	13.6	8/26	14.0	8/29	12.8	97.9
MitsuiCD	07011401	1	2000	1:12	12.9	8/1	13.3	7/31	13.6	9/19	12.7	97.9
MitsuiTD	07011402	2	1996	1:12	11.8	8/31	12.0	8/30	12.0	8/27	11.4	63.0
MitsuiTD	07011402	2	1997	1:12	12.9	9/3	13.0	9/5	13.1	9/3	12.8	63.0
MitsuiTD	07011402	2	1998	1:12	12.3	8/16	12.4	8/14	12.5	8/12	12.2	63.0
MitsuiTD	07011402	2	1999	1:12	12.3	8/27	12.4	8/27	12.5	8/26	12.3	63.0
MitsuiTD	07011402	2	2000	1:12	12.5	9/19	12.7	9/19	13.0	9/18	12.7	63.0
MitsuiTU	07011403	2	1996	1:12	12.1	8/30	12.2	8/30	12.5	9/15	12.0	47.0
MitsuiTU	07011403	2	1997	1:12	14.0	8/27	14.1	8/26	14.6	8/26	14.0	47.0
MitsuiTU	07011403	2	1998	1:12	14.3	7/24	14.4	7/23	14.6	7/26	14.3	47.0
MitsuiTU	07011403	2	1999	1:12	13.6	8/27	13.6	8/27	13.7	8/27	13.6	47.0
MitsuiTU	07011403	2	2000	1:12	13.4	8/3	13.4	8/2	13.6	8/1	13.4	47.0

GREEN DIAMOND AHCP/CCAA

**Table C5-8 Continued. Summer water temperature monitoring summary, Little River HPA.**

Stream Name	Site ID	Class	Year	Interval	7DMAVG	Mid Date (7DMAVG)	7DMMX	Mid Date (7DMMX)	Max	Max Date	Min after Max	Area (acres)
Little River, Upper SF	07020601	1	1994	2:00	14.5	8/19	15.9	8/16	16.2	8/3	14.0	3619.0
Little River, Upper SF	07020601	1	1995	2:00	14.7	8/3	16.5	8/3	17.0	7/31	13.7	3619.0
Little River, Upper SF	07020601	1	1998	1:12	15.0	8/14	16.5	7/20	16.8	7/18	13.7	3619.0
Little River, Upper SF	07020601	1	1999	0:36	14.8	8/27	15.2	8/27	15.6	8/29	14.5	3619.0
Little River, Upper SF	07020601	1	2000	1:12	15.3	7/31	16.5	7/31	16.8	8/1	14.6	3619.0
Little River Headwaters	07021401	2	1996	2:24	12.7	7/28	13.3	7/28	13.4	7/28	12.5	468.0
Little River Headwaters	07021401	2	1997	2:24	12.1	8/10	12.4	8/9	12.9	8/7	12.3	468.0
Little River Headwaters	07021401	2	1998	2:30	12.4	8/30	12.7	8/30	13.1	8/29	12.2	468.0
Little River Headwaters	07021401	2	1999	1:12	11.6	8/26	11.8	8/26	12.2	8/26	11.9	468.0
Little River Headwaters	07021401	2	2000	1:12	11.8	8/3	12.1	8/2	12.4	8/2	12.0	468.0
M155TD	07021801	2	1999	1:12	12.2	8/27	12.4	8/27	12.6	8/29	11.4	26.5
M155TD	07021801	2	2000	1:12	12.4	9/18	12.7	9/18	13.3	9/19	12.5	26.5
M155TU	07021802	2	1999	1:12	12.8	8/27	13.2	8/27	13.6	8/27	12.7	21.2
M155TU	07021802	2	2000	1:12	14.1	9/17	14.9	9/17	16.3	9/19	14.0	21.2
Railroad	08013401	1	1994	2:00	14.4	8/19	15.7	8/19	15.9	8/19	13.3	1721.0
Railroad	08013401	1	1995	2:00	14.4	7/29	15.6	7/29	15.9	7/31	13.4	1721.0
Railroad	08013401	1	1998	1:12	14.6	8/14	15.5	8/13	15.9	7/19	14.0	1721.0
Railroad	08013401	1	1999	0:36	15.0	8/27	16.8	8/23	17.5	8/29	14.4	1721.0
Railroad	08013401	1	2000	1:12	15.2	7/31	16.3	7/31	16.6	8/1	14.7	1721.0
Little River, Lower SF	08013601	1	1994	2:00	14.6	7/24	16.3	8/5	16.9	8/3	14.5	3452.0
Little River, Lower SF	08013601	1	1995	2:00	15.2	7/30	16.7	8/3	17.2	8/1	14.0	3452.0
Little River, Lower SF	08013601	1	1998	1:12	15.9	7/23	17.4	7/23	18.1	7/26	15.2	3452.0
Little River, Lower SF	08013601	1	1999	0:36	15.6	8/27	16.5	8/23	17.2	8/22	14.5	3452.0
Little River, Lower SF	08013601	1	2000	1:12	16.1	7/31	18.0	7/31	18.5	8/1	15.2	3452.0
Little River (mid)	08013602	1	1994	1:36	15.2	7/30	16.4	7/29	16.9	7/31	14.4	13176.3
Little River (mid)	08013602	1	1996	2:00	16.0	7/28	17.5	7/28	17.9	7/29	14.8	13176.3
Little River (mid)	08013602	1	1999	1:12	15.5	8/27	16.2	8/27	16.6	8/29	15.3	13176.3
Little River (mid)	08013602	1	2000	1:12	15.8	7/31	17.0	7/31	17.4	8/1	15.0	13176.3
Danielle	08013603	1	2000	1:12	14.2	7/31	16.0	7/31	16.4	8/1	13.4	479.2
Heightman	08013604	1	2000	1:12	13.6	8/1	14.0	7/31	14.3	8/1	13.4	688.3
Little River (upper)	08022901	1	1994	2:00	13.4	8/21	14.2	8/21	14.5	8/19	13.3	8755.0
Little River (upper)	08022901	1	1995	2:00	14.0	8/3	15.2	8/3	15.8	7/31	13.3	8755.0
Little River (upper)	08022901	1	1996	2:00	14.1	7/28	15.3	7/27	15.8	7/30	12.6	8755.0
Little River (upper)	08022901	1	1999	1:12	14.1	8/27	14.7	8/27	15.3	8/29	13.1	8755.0
Little River (upper)	08022901	1	2000	1:12	14.3	9/18	15.1	9/18	16.1	9/19	13.9	8755.0
Little River (up98)	08023101	1	1998	1:12	15.3	8/14	17.0	8/14	17.4	7/26	14.3	9557.0
C-Line	08023201	1	2000	1:12	13.7	9/18	14.1	9/18	15.0	9/19	13.4	788.0

GREEN DIAMOND AHCP/CCAA

**Table C5-9. Summer water temperature monitoring summary, Mad River HPA.**

Stream Name	Site ID	Class	Year	Interval	7DMAVG	Mid Date (7DMAVG)	7DMMX	Mid Date (7DMMX)	Max	Max Date	Min after Max	Area (acres)
Boulder Trib	04030301	2	1996	1:12	13.2	8/31	13.8	8/31	14.7	8/24	12.7	190.0
Boulder	04030501	1	1994	1:12	16.6	8/17	19.6	8/17	20.1	8/14	14.0	11617.1
Boulder	04030501	1	1995	1:12	16.7	8/3	18.3	8/3	18.8	7/16	15.2	11617.1
Boulder	04030501	1	1997	1:12	18.1	8/9	20.8	8/6	21.6	8/7	15.8	11617.1
Boulder	04030501	1	1998	1:12	17.7	7/25	20.1	8/13	21.2	7/26	16.4	11617.1
Boulder	04030501	1	1999	1:12	17.2	8/26	19.6	7/12	20.6	7/13	14.4	11617.1
Goodman Prairie	04032902	1	1999	1:12	15.2	8/26	15.9	8/26	16.3	8/29	14.1	938.0
Goodman Prairie	04032902	1	2000	1:12	15.3	9/18	16.3	9/18	17.0	9/19	15.0	938.0
Graham	04033501	2	1996	1:12	12.6	8/17	13.4	8/17	13.6	8/17	11.4	723.0
Cañon (high)	05020101	1	1994	1:12	14.9	8/17	15.9	8/16	16.2	8/14	14.0	6421.0
Cañon (high)	05020101	1	1999	1:12	16.0	8/26	17.1	8/26	17.8	8/29	14.6	6421.0
Black Dog Treatment/5300	05020701	2	1999	1:12	11.8	8/27	12.0	8/27	12.4	8/27	11.9	92.0
Dry	05020801	1	1994	1:12	12.1	8/17	13.1	6/26	13.4	6/23	10.2	1601.0
Dry	05020801	1	1999	1:12	13.2	8/27	14.2	6/24	15.2	6/22	11.3	1601.0
Black Dog	05020802	2	1996	2:24	13.0	7/28	13.5	7/27	13.7	7/28	12.8	503.0
Black Dog	05020802	2	1997	2:24	14.2	9/3	14.4	9/3	14.6	8/26	14.0	503.0
Black Dog	05020802	2	1998	2:30	13.3	7/19	13.8	7/19	14.0	7/16	12.8	503.0
Black Dog	05020802	2	1999	1:12	13.3	8/26	13.6	8/26	13.9	8/26	13.4	503.0
Cañon (low)	05021001	1	1994	1:12	16.7	8/17	18.5	7/16	19.1	7/18	14.3	9869.0
Cañon (low)	05021001	1	1995	1:12	16.9	8/4	18.4	7/29	19.4	7/16	15.5	9869.0
Cañon (low)	05021001	1	1996	1:12	17.7	7/28	19.4	7/6	19.9	7/6	15.1	9869.0
Cañon (low)	05021001	1	1997	1:12	18.8	7/17	21.6	7/17	22.1	7/15	16.7	9869.0
Cañon (low)	05021001	1	1998	0:08	18.5	7/24	20.6	7/18	21.2	7/19	17.0	9869.0
Cañon (low)	05021001	1	1999	1:12	17.6	8/24	18.9	8/24	20.0	6/22	14.7	9869.0
Cañon (low)	05021001	1	2000	1:12	18.2	8/1	20.0	6/26	21.1	6/27	16.1	9869.0
Cañon (mid)	05021201	1	1994	1:12	15.8	8/17	18.0	8/17	18.4	8/14	13.1	8620.0
Cañon (mid)	05021201	1	1999	1:12	16.8	8/27	17.4	8/24	17.8	7/11	15.3	8620.0
Cañon (mid)	05021201	1	2000	1:12	17.9	8/1	19.6	8/1	20.3	8/1	16.6	8620.0
Green Diamond	05021401	1	1997	1:12	15.3	9/3	16.4	7/21	17.0	8/7	13.9	226.5
Green Diamond	05021401	1	1999	1:12	15.1	8/27	16.2	8/26	16.8	8/29	14.0	226.5
Mad River Trib. #1	05021601	2	1995	1:12	12.8	8/3	13.3	8/2	13.7	7/31	12.5	30.5
Mad River Trib. #2	05021602	2	1995	1:12	14.1	7/30	15.1	7/30	15.5	7/16	13.1	38.5
Mad River Trib. #3	05021603	2	1995	1:12	12.6	8/4	12.8	8/2	12.8	7/27	12.2	38.4
Mad River Trib. #4	05021604	2	1995	1:12	14.0	8/3	15.3	7/29	16.5	7/31	13.4	74.5
6001CD	05021605	2	1996	1:12	12.0	7/28	12.1	7/28	12.2	7/28	12.0	26.5
6001CD	05021605	2	1997	1:12	12.8	9/3	13.0	8/27	13.1	8/26	12.8	26.5
6001CD	05021605	2	1998	1:12	12.3	8/14	12.5	7/23	12.8	7/26	12.2	26.5
6001CD	05021605	2	1999	1:12	12.1	8/27	12.3	8/26	12.5	8/26	12.3	26.5

GREEN DIAMOND AHCP/CCAA

**Table C5-9 Continued. Summer water temperature monitoring summary, Mad River HPA.**

Stream Name	Site ID	Class	Year	Interval	7DMAVG	Mid Date (7DMAVG)	7DMMX	Mid Date (7DMMX)	Max	Max Date	Min after Max	Area (acres)
6001CD	05021605	2	2000	1:12	12.6	9/18	12.8	9/18	13.0	9/18	12.7	26.5
6001CU	05021606	2	1996	1:12	11.6	8/30	11.7	8/30	11.9	7/29	11.6	10.2
6001CU	05021606	2	1997	1:12	12.7	9/3	12.8	9/3	12.8	8/29	12.2	10.2
6001CU	05021606	2	1998	1:12	12.1	9/5	12.2	9/3	12.3	7/26	12.0	10.2
6001CU	05021606	2	1999	1:12	12.5	8/27	12.7	8/27	12.9	8/26	12.6	10.2
6001CU	05021606	2	2000	1:12	12.8	9/18	13.1	9/18	13.7	9/18	13.0	10.2
6001TD	05021607	2	1996	1:12	12.7	7/28	13.5	7/27	13.8	7/28	12.4	62.5
6001TD	05021607	2	1997	1:12	13.3	9/3	13.6	9/1	13.9	8/7	12.4	62.5
6001TD	05021607	2	1998	1:12	13.6	8/14	14.9	8/13	15.4	7/26	13.1	62.5
6001TD	05021607	2	1999	1:12	13.4	8/26	14.1	8/24	14.3	8/22	12.5	62.5
6001TD	05021607	2	2000	1:12	13.4	9/17	14.4	7/31	14.7	6/27	12.2	62.5
5410CU	05021608	2	1996	1:12	12.3	7/28	13.1	8/30	13.3	7/29	11.9	854.9
5410CU	05021608	2	1997	1:12	12.6	9/4	13.1	9/4	13.4	9/6	11.6	854.9
5410CU	05021608	2	1998	1:12	12.0	9/5	12.7	9/5	12.9	9/4	11.4	854.9
5410CU	05021608	2	1999	1:12	11.6	8/27	11.8	8/26	12.0	8/29	11.2	854.9
5410TD	05021701	2	1996	1:12	12.2	8/29	12.5	8/30	12.7	8/30	12.2	365.0
5410TD	05021701	2	1998	1:12	12.9	8/14	13.1	8/4	13.3	7/26	12.6	365.0
5410TD	05021701	2	1999	1:12	12.5	8/27	12.7	8/23	12.8	8/21	12.2	365.0
5410TD	05021701	2	2000	1:12	12.7	9/17	13.0	7/31	13.2	9/19	12.7	365.0
5410TU	05021702	2	1996	1:12	12.5	7/28	12.7	7/28	13.0	7/30	12.0	187.9
5410TU	05021702	2	1997	1:12	13.8	9/3	13.9	9/1	14.1	8/29	13.3	187.9
5410TU	05021702	2	1998	1:12	13.1	9/5	13.5	9/3	14.0	9/3	13.4	187.9
5410TU	05021702	2	1999	1:12	13.4	8/26	14.0	8/26	14.3	8/26	14.0	187.9
5410TU	05021702	2	2000	1:12	13.1	9/18	13.5	6/27	14.3	6/27	13.3	187.9
5410CD	05021703	2	1996	1:12	13.6	7/28	14.3	7/28	14.5	7/28	13.3	885.8
5410CD	05021703	2	1997	1:12	14.0	9/4	14.3	9/4	14.5	8/7	13.4	885.8
5410CD	05021703	2	1998	1:12	13.3	8/14	14.2	7/24	14.5	7/26	12.9	885.8
5410CD	05021703	2	1999	1:12	13.3	8/27	13.6	8/27	13.9	8/29	12.6	885.8
5410CD	05021703	2	2000	1:12	13.3	8/1	14.0	7/31	14.3	8/1	12.9	885.8
6001TU	05022101	2	1996	1:12	12.3	7/31	12.5	8/30	12.7	8/12	12.2	43.9
6001TU	05022101	2	1997	1:12	12.6	9/14	12.7	9/14	12.8	9/17	12.5	43.9
6001TU	05022101	2	1998	1:12	12.9	7/25	12.9	7/22	12.9	7/19	12.8	43.9
6001TU	05022101	2	1999	1:12	12.3	8/26	12.8	8/24	13.3	8/26	12.3	43.9
6001TU	05022101	2	2000	1:12	12.4	9/17	13.2	9/18	14.0	9/18	12.2	43.9
Mad River Trib. #5	05022201	2	1995	1:12	13.7	7/30	14.1	8/2	14.6	8/1	13.1	356.7
Mad River Trib. #6	05022202	2	1995	1:12	13.6	7/30	14.0	7/30	14.3	7/31	13.4	242.4
Mad River Trib. #7	05022203	2	1995	1:12	13.5	7/30	13.9	7/29	14.6	7/31	13.4	149.9
Devil	05022301	1	1997	1:12	14.5	9/6	14.5	9/4	14.6	9/6	14.5	1447.6
Devil	05022301	1	1999	1:12	14.5	8/27	15.0	8/27	15.2	8/26	14.6	1447.6

GREEN DIAMOND AHCP/CCAA

**Table C5-9 Continued. Summer water temperature monitoring summary, Mad River HPA.**

Stream Name	Site ID	Class	Year	Interval	7DMAVG	Mid Date (7DMAVG)	7DMMX	Mid Date (7DMMX)	Max	Max Date	Min after Max	Area (acres)
Cañon (class II)	05030801	2	1996	1:12	12.4	8/17	12.9	8/17	13.3	8/24	12.0	260.9
Maple (Mad)	05033001	1	1994	1:12	14.1	8/17	15.5	8/16	15.9	8/14	12.0	7496.0
Maple (Mad)	05033001	1	1996	1:12	16.8	7/28	20.4	7/28	21.1	7/30	14.5	7496.0
Maple (Mad)	05033001	1	1997	1:12	16.4	8/9	19.0	8/6	19.6	8/7	14.6	7496.0
Maple (Mad)	05033001	1	1999	1:12	15.7	8/26	17.6	8/23	18.4	8/29	14.1	7496.0
Mill Cr (Mck.)	06010401	1	1997	1:12	13.3	8/27	13.7	8/27	14.0	9/17	12.3	704.6
Lindsay	06011101	1	1994	1:12	15.9	8/18	16.8	8/17	17.1	8/19	15.2	8811.0
Lindsay	06011101	1	1995	1:12	15.9	7/29	17.1	7/29	17.8	7/16	15.2	8811.0
Lindsay	06011101	1	1996	1:12	15.9	7/28	16.6	7/28	17.2	7/30	15.0	8811.0
Lindsay	06011101	1	1997	1:12	16.1	7/18	16.9	7/17	17.3	7/7	14.8	8811.0
Lindsay	06011101	1	1998	0:08	15.8	8/14	16.8	8/13	17.4	7/15	14.5	8811.0
Lindsay	06011101	1	1999	1:12	15.3	8/24	16.2	8/24	17.1	8/29	14.9	8811.0
Lindsay	06011101	1	2000	1:12	15.4	7/31	16.0	7/31	16.3	8/1	15.0	8811.0

GREEN DIAMOND AHCP/CCAA

**Table C5-10. Summer water temperature monitoring summary, North Fork Mad River HPA.**

Stream Name	Site ID	Class	Year	Interval	7DMAVG	Mid Date (7DMAVG)	7DMMX	Mid Date (7DMMX)	Max	Max Date	Min after Max	Area (acres)
Mule	06020301	1	1996	1:12	13.0	8/30	15.1	8/31	15.6	8/31	11.6	338.7
Mule	06020301	1	2000	1:12	13.4	8/2	14.0	8/1	14.3	8/1	12.9	338.7
Jackson	06020302	1	1998	1:12	13.6	7/25	13.9	7/25	14.2	7/26	13.6	511.0
Jackson	06020302	1	1999	1:12	13.2	8/27	13.6	8/26	13.7	8/29	12.5	511.0
Denman	06020303	1	2000	1:12	15.3	9/17	17.0	9/17	18.1	9/18	14.2	878.2
Long Prairie	06021101	1	1994	1:12	14.2	8/17	15.4	8/17	15.5	8/14	12.8	6231.0
Long Prairie	06021101	1	1998	0:08	14.9	7/24	16.0	7/24	16.6	7/26	14.4	6231.0
Long Prairie	06021101	1	1999	1:12	14.8	8/26	15.6	8/26	16.1	8/29	13.4	6231.0
Gossinta	06021102	1	2000	1:12	15.0	9/17	17.9	9/19	19.7	9/18	13.8	730.9
Pollock	06021401	1	1996	2:24	13.7	7/29	14.0	7/28	14.3	7/29	13.7	1060.3
Pollock	06021401	1	1997	2:24	14.5	9/3	14.9	9/3	15.1	8/7	13.7	1060.3
Pollock	06021401	1	1998	2:30	13.9	8/10	14.6	8/9	15.2	7/23	13.4	1060.3
Pollock	06021401	1	1999	1:12	13.6	8/27	13.8	8/27	13.9	8/29	13.3	1060.3
Bald Mountain	06021402	1	1999	1:12	14.2	8/26	14.7	8/26	14.9	8/29	13.4	3008
Poverty	06021501	1	1999	1:12	14.1	8/26	15.7	8/26	16.4	8/29	10.5	404.4
Jiggs	06022201	2	1996	2:24	12.9	7/28	13.3	7/27	13.4	7/25	12.2	664.9
Jiggs	06022201	2	1997	2:24	13.7	9/3	14.5	8/5	14.6	8/7	13.1	664.9
Jiggs	06022201	2	1998	2:30	12.9	8/10	13.4	7/19	13.7	7/22	12.5	664.9
Jiggs	06022201	2	1999	1:12	13.4	8/26	14.5	8/25	14.8	8/26	13.1	664.9
NF Mad (middle)	06022301	1	1994	1:12	17.1	8/17	18.7	8/17	18.8	8/14	15.5	23462.9
NF Mad (middle)	06022301	1	1999	1:12	17.3	8/26	19.0	7/12	19.6	7/13	14.5	23462.9
NF Mad (middle)	06022301	1	2000	1:12	17.3	8/1	19.8	7/31	20.2	8/1	15.6	23462.9
Jiggs Upper	06022601	2	1999	1:12	12.9	8/26	13.1	8/26	13.7	8/27	13.0	421.5
Sullivan Gulch	06022801	1	1997	1:12	15.2	9/3	15.9	7/16	16.3	7/18	13.9	1536.0
Sullivan Gulch	06022801	1	1999	1:12	14.6	8/27	15.1	8/24	15.9	6/22	12.5	1536.0
Sullivan Gulch	06022801	1	2000	1:12	14.9	7/31	15.6	6/17	16.2	6/27	13.5	1536.0
NF Mad (lower)	06022802	1	1994	1:12	17.7	7/17	20.3	8/16	20.5	8/14	15.5	27634.0
NF Mad (lower)	06022802	1	1995	1:12	18.4	8/3	20.7	8/2	21.5	7/16	16.2	27634.0
NF Mad (lower)	06022802	1	1996	1:12	19.7	7/28	21.4	7/28	21.9	7/30	18.1	27634.0
NF Mad (lower)	06022802	1	1997	1:12	19.5	7/17	22.4	8/5	23.2	8/7	17.2	27634.0
NF Mad (lower)	06022802	1	1998	1:12	18.9	7/23	21.8	8/13	22.6	8/13	17.4	27634.0
NF Mad (lower)	06022802	1	1999	1:12	17.8	8/23	20.4	7/14	21.2	8/22	16.2	27634.0
NF Mad (lower)	06022802	1	2000	1:12	19.0	8/1	21.1	8/1	22.0	6/27	16.5	27634.0

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**Table C5-10 Continued. Summer water temperature monitoring summary, North Fork Mad River HPA.**

Stream Name	Site ID	Class	Year	Interval	7DMAVG	Mid Date (7DMAVG)	7DMMX	Mid Date (7DMMX)	Max	Max Date	Min after Max	Area (acres)
NF Mad (site 1a)	06022803	1	1998	1:12	18.8	8/14	22.3	8/13	23.1	8/12	16.6	26613.0
Watek	06023201	1	1996	1:12	12.1	8/28	13.4	8/30	13.7	8/31	10.5	615.8
East Fork North Fork Mad	07022201	2	1996	2:24	14.1	7/28	14.4	7/28	14.6	7/30	13.7	153.7
Canyon (class II)	07022601	2	1996	2:24	14.6	7/28	15.1	7/28	15.2	7/14	14.0	847.5
Canyon (class II)	07022601	2	1997	2:24	14.0	8/10	14.4	8/10	14.8	8/8	13.9	847.5
Canyon (class II)	07022601	2	1998	2:30	14.2	8/30	14.6	7/21	15.5	7/22	13.7	847.5
Canyon (class II)	07022601	2	1999	1:12	13.8	8/26	14.2	8/26	14.6	7/13	12.3	847.5
Canyon (class II)	07022601	2	2000	1:12	13.8	6/27	14.7	6/27	15.8	6/28	13.2	847.5
Canyon RHVA 1	07022701	2	2000	1:12	13.4	9/19	13.7	9/19	14.4	9/20	13.1	28.1
Canyon RHVA 2	07022702	2	2000	1:12	12.0	9/20	12.3	9/20	12.9	9/20	11.8	95.4
NF Mad (upper)	07022801	1	1994	1:12	13.9	8/17	14.9	8/17	15.2	8/20	12.5	5252.6
NF Mad (upper)	07022801	1	1999	1:12	14.5	8/26	15.2	8/26	15.6	8/29	13.3	5252.6
NF Mad (upper)	07022801	1	2000	1:12	14.7	8/1	15.3	8/1	15.9	6/28	13.7	5252.6
Canyon	07022802	1	1997	1:12	14.4	8/9	15.3	8/9	15.9	8/7	13.7	1870.2
Canyon	07022802	1	1998	1:12	14.0	9/4	15.1	9/3	15.6	9/3	13.4	1870.2
Canyon	07022802	1	1999	1:12	14.0	8/26	14.6	8/26	14.8	8/26	14.0	1870.2
East Fork of North Fork	07022803	1	2000	1:12	13.5	8/2	14.1	8/1	14.6	6/28	12.8	1276.6
Krueger	07023401	1	2000	1:12	14.1	8/2	14.5	8/1	14.8	8/1	13.8	708.9
Railroad (NF Mad)	07023402	1	2000	1:12	13.4	8/3	13.5	8/1	13.7	8/1	13.3	545.3



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**Table C5-11. Summer water temperature monitoring summary, Humboldt Bay HPA.**

Stream Name	Site ID	Class	Year	Interval	7DMAVG	Mid Date (7DMAVG)	7DMMX	Mid Date (7DMMX)	Max	Max Date	Min after Max	Area (acres)
Salmon (high)	03011801	1	1994	1:12	13.7	8/19	14.1	8/16	14.3	8/19	13.4	3294.3
Salmon (high)	03011801	1	1999	1:12	15.2	8/24	16.7	8/24	17.3	8/22	14.3	3294.3
Salmon (high)	03011801	1	2000	1:12	15.1	7/31	16.0	7/31	16.7	6/27	13.7	3294.3
Salmon (low)	03510901	1	1995	1:12	16.0	7/16	17.2	7/15	18.1	7/16	15.5	7858.0
Salmon (low)	03510901	1	1996	1:12	16.1	7/28	17.3	7/28	17.7	7/28	15.9	7858.0
Salmon (low)	03510901	1	1997	1:12	18.1	8/5	20.5	8/5	20.9	8/3	15.9	7858.0
Salmon (low)	03510901	1	1998	0:08	17.4	7/17	19.3	7/16	20.1	7/15	16.0	7858.0
Salmon (low)	03510901	1	1999	1:12	16.6	8/23	17.7	8/22	18.5	6/22	14.6	7858.0
Salmon (low)	03510901	1	2000	1:12	16.7	7/29	17.8	7/29	18.9	6/27	15.2	7858.0
Salmon (mid)	03511001	1	1994	1:12	15.8	8/19	16.4	8/17	16.8	8/14	14.6	6979.0
Ryan (upper)	04011801	1	1994	2:00	14.7	8/19	15.7	8/20	16.1	8/19	14.6	1154.6
Ryan (upper)	04011801	1	1995	2:00	15.2	7/26	15.9	7/16	16.8	7/27	15.2	1154.6
Ryan (upper)	04011801	1	1997	2:00	14.9	7/18	15.3	7/22	15.9	7/24	13.7	1154.6
Ryan (upper)	04011801	1	1999	1:12	14.9	8/24	15.4	8/24	15.8	8/22	14.3	1154.6
Henderson	04510101	1	1997	2:00	14.2	9/4	14.5	9/4	14.8	9/5	14.2	922.6
Henderson	04510101	1	1999	1:12	13.5	8/27	13.7	8/26	14.0	8/26	13.3	922.6
Henderson	04510101	1	2000	1:12	13.4	7/31	13.5	7/31	13.8	7/31	13.5	922.6
Guptil	04511201	1	1997	2:00	14.9	9/3	15.5	8/26	16.1	8/25	14.9	1146.2
Guptil	04511201	1	1999	1:12	14.2	8/27	14.4	8/27	14.8	8/29	13.9	1146.2
Guptil	04511201	1	2000	1:12	13.8	7/31	14.2	7/31	14.3	7/31	13.9	1146.2
Bear Ryan	04511202	1	1999	1:12	13.5	8/27	13.7	8/27	14.0	8/29	13.3	719.2
Bear Ryan	04511202	1	2000	1:12	13.5	7/31	13.8	7/31	14.1	8/1	13.1	719.2
Ryan, SF	04511302	1	1997	2:00	14.9	7/18	16.5	7/20	17.0	7/18	13.4	1799.2
Ryan, SF	04511302	1	2000	1:12	14.6	7/31	15.1	7/31	15.4	8/1	14.1	1799.2
Morrison	05011401	1	1997	1:12	14.8	9/3	15.3	9/3	15.8	7/18	13.1	575.0
Morrison	05011401	1	1998	1:12	14.1	8/14	15.2	8/13	15.4	8/12	13.6	575.0
Morrison	05011401	1	1999	1:12	13.9	8/27	14.4	8/23	14.6	8/22	13.1	575.0
Morrison	05011401	1	2000	1:12	13.8	9/18	14.3	7/31	14.7	8/1	13.5	575.0
Rocky	05011501	1	1999	1:12	12.4	8/27	12.4	8/27	12.5	8/22	12.2	465.8
Jacoby (low)	05012401	1	1994	1:12	13.5	8/17	14.7	8/16	14.9	8/14	11.7	4345.0
Jacoby (high)	05023001	1	1994	1:12	12.4	8/17	13.9	8/16	14.3	8/14	10.8	1128.4
Ryan (low)	05513601	1	1997	2:00	15.6	9/3	16.3	9/3	16.9	9/5	14.8	7341.1
Ryan (low)	05513601	1	1998	1:12	15.1	8/13	15.7	8/13	16.1	8/13	14.5	7341.1
Ryan (low)	05513601	1	1999	1:12	14.8	8/24	15.3	8/24	15.9	8/22	14.3	7341.1
Ryan (low)	05513601	1	2000	1:12	14.8	7/31	15.3	7/31	15.6	7/28	15.0	7341.1

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**Table C5-12. Summer water temperature monitoring summary, Eel River HPA.**

Stream Name	Site ID	Class	Year	Interval	7DMAVG	Mid Date (7DMAVG)	7DMMX	Mid Date (7DMMX)	Max	Max Date	Min after Max	Area (acres)
Slater	01510101	1	1997	1:12	14.4	7/8	14.9	7/8	15.3	7/8	14.5	1133.0
Slater	01510101	1	1998	0:08	14.9	7/20	15.5	7/18	15.8	7/18	14.7	1133.0
Slater	01510101	1	1999	1:12	14.1	8/27	14.5	8/12	14.8	8/29	13.4	1133.0
Wilson (VanD)	02012301	1	1997	1:12	15.3	9/3	15.9	9/3	16.3	9/4	15.3	686.2
Wilson (VanD)	02012301	1	1998	0:08	14.3	8/13	15.1	8/13	15.5	8/12	13.6	686.2
Wilson (VanD)	02012301	1	1999	1:12	14.3	8/24	15.0	8/23	15.6	8/29	13.3	686.2
Cuddeback	02012302	1	1998	0:08	14.2	8/13	14.9	8/13	15.2	8/12	13.8	558.0
Cuddeback	02012302	1	1999	1:12	14.0	8/27	14.4	8/23	14.9	8/29	13.4	558.0
Felder	02012501	1	1999	1:12	14.0	8/26	14.4	8/23	14.6	8/22	13.7	109.5
Felder	02012501	1	2000	1:12	13.8	7/31	14.2	7/31	14.3	7/29	13.7	109.5
Stevens	02023501	1	1999	1:12	16.4	8/26	19.3	8/23	20.5	8/29	14.6	506.9
Stevens	02023501	1	2000	1:12	16.6	7/31	18.4	7/31	19.0	7/29	15.9	506.9

The nomenclature changed as well. The term MWAT (Maximum Weekly Average Temperature) is a specific threshold determined for a particular life stage and species (Armour 1991). MWAT is a fixed value for a specific species, not a field measurement that varies by stream. The more appropriate term is 7DMAVG (Seven-Day Moving Average) which is the highest average temperature out of all possible seven consecutive days. The 7DMAVG may or may not include the absolute maximum temperature or the 7DMMX recorded during the season. The maximum temperature often occurs later in the fall during low flow conditions that coincide with the loss of deciduous canopy and a reduced coastal marine layer influence. During this time of year the daily peaks may be high but the daily average, due to overnight cooling, will be less than the mid summer peaks.

#### **C5.1.2.2 Methods**

Green Diamond continues to use Onset Computer Corporation's temperature data loggers although the HOBO® models are being phased out for a variety of reasons. The reliability of the HOBO® models came into question when calibration of the units began to occur annually. Even with regular maintenance and battery exchanges the thermographs failed more frequently as they aged. Advances in memory capacity and battery life provided for a new model known as a TidbiT®. The TidbiT® has the same accuracy as the HOBO® HTI –05/37°C, 3 years more battery life, almost 18 times more memory and it is water proof. Every thermograph is calibrated (see Appendix D) to confirm its reliability. Individual recorders with identical measurements are used in Paired Watershed BACI experiments (see Objectives and Methods-Class II Paired Watershed Streams below). With the introduction of the TidbiT® the length of deployment became less of a concern yet the primary monitoring window remained from July through September. Early attempts at modifying the recording interval to capture as much data as the thermograph was capable of only produced huge files that were difficult to analyze. For instance a Tidbit® launched at 8-minute intervals (0.13 hours) will record 180 records per day and last 180 days before the memory is full. Analysis again confirmed that an interval of 1.2 hours would capture the necessary details of the diurnal extremes. The recording interval was kept at 1.2 hours.

In addition to the Class I monitoring Green Diamond began a program of Class II monitoring in headwater streams known to have populations of Tailed Frogs or Torrent Salamanders. All of the methods apply to both classes of streams with a few exceptions. Due to the small size of many of the Class II watercourses the actual placement of the recorders tended to be in deeper water in order to avoid the possibility of late summer dewatering. Also, the Class II sites were frequently associated with other biological monitoring and thus are not necessarily at the lowest point in the sub-watershed.

Other site-specific variables are collected at every temperature-monitoring site or measured from maps, aerial photos or GIS. The inclusion of specific variables will help in the interpretation of the thermograph data. These variables currently include canopy closure, stream aspect, channel dimensions, flow and watershed area. Green Diamond has cooperated extensively during this period with the Forest Science Project's "*Regional Assessment of Stream Temperatures Across Northern California and Their Relationship to Various Landscape – Level and Site – Specific Attributes*". The previous

list of variables and more were collected for and contributed to the FSP for inclusion in the regional temperature analysis.

Green Diamond has also acquired temperature profiles from other agencies and landowners that have worked within or near the HPAs. Louisiana Pacific (LP) monitored temperature in several Class I watercourses across their ownership in Humboldt County. When Green Diamond purchased the LP property in 1998, it also acquired these data files along with site location maps dating back to 1994. Green Diamond and LP were active participants in the Fish, Farm, and Forest Community effort to establish standardized monitoring methods in order to conduct regional temperature evaluations such as the FSP's "*Regional Assessment of Stream Temperatures Across Northern California and Their Relationship to Various Landscape – Level and Site – Specific Attributes*". LP's methods were comparable to Green Diamond's and as a result their historic data has been assimilated into the database. Many of the LP sites have become some of Green Diamond's annual monitoring stations. The Yurok Tribal Fisheries Program (YTFP) has extensively monitored the tributaries as well as the main stem of the lower Klamath River. This is a coordinated effort to make the best use of respective resources and avoid repetitive monitoring of specific sites. The YTFP and Green Diamond share the same monitoring methods and thus resulting data files for the Klamath area. Several agencies such as the California Conservation Corp, California Department of Fish and Game, National Park Service, the United States Fish and Wildlife Service and the US Forest Service have all monitored stream temperature on or near Green Diamond Property. Unfortunately most of these monitoring efforts are not coordinated with Green Diamond or potentially have different methods and protocols. As a result these data must be evaluated on a case by case basis as to whether or not to include them in the database.

#### **C5.1.2.3 Results**

At the end of the year 2000, Green Diamond has recorded and/or collected 400 temperature profiles in approximately 108 Class I watercourses and 210 temperature profiles in approximately 70 Class II watercourses. All of these profiles have been processed to calculate the 7DMAVG, 7DMMX, absolute maximum, and the minimum following the maximum temperatures as well as the associated dates of occurrence. Various attributes have been collected for many of these monitoring stations, specifically watershed area. Temperature monitoring data are summarized and shown in Tables C5-2 through 12.

#### **C5.1.2.4 Discussion**

The monitoring window from mid-June through mid-September generally captures the seasonal peak 7DMAVG temperature. On occasion 7DMAVG temperatures in late September and early October were documented. In several stream reaches, maximum water temperatures occurred in late September (upper Dominie Creek, lower Savoy Creek, and Upper South Fork Winchuck River) [Smith River HPA]. These late occurring maximum temperatures were probably affected in part by diminishing stream flow, since the photoperiod of maximum daylight hours and sun angle had occurred two months earlier. Also, the geography of coastal northern California may promote the late occurrence of maximum stream temperatures. A dense band of marine fog that often extends up coastal stream courses is common during June and July. By mid-August this

marine layer starts to break up, and the rest of the late summer/early fall is generally clear and warm prior to the onset of fall and winter rains. Finally, the deciduous habit of alders and willows in riparian areas may influence late peak temperatures.

Of the 400 Class I records for the period 1994 to 2000, 375 (93.8%) were at or below the "Inter-agency Matrix" suggested MWAT threshold of 17.4°C. Green Diamond believes that the single MWAT threshold value fails to account for natural variations in water temperature due to geographic location, climatic factors and drainage area of the monitored sub-basin. Also, depending on the method used to test the upper incipient lethal temperature of juvenile salmonids, a critical MWAT can range from 16.8°C to 18.4°C (Armour 1991; Thomas et al. 1986; Becker and Genoway 1979). Stream and watershed specific factors create a wide variation in processes that affect water temperatures (Beschta et al. 1987). The relationship of water temperature and watershed area was examined to help account for the observed natural variation in water temperature. The data suggests that water temperature was positively associated with watershed area and was relatively predictable for watershed areas up to 10,000 acres. Above 10,000 acres, the temperature variation increased probably in response to the complex interacting physical factors (Beschta et al. 1987).

Of the 25 records that were above the suggested MWAT threshold, 17 had watershed areas of more than 10,000 acres above the monitoring site. The 8 records that exceeded the 17.4°C threshold and had watershed areas less than 10,000 acres occurred in 6 different streams. The higher temperatures appear to be caused by either variations in climatic factors or by a flood event that set back the riparian vegetation. For example, in the winter of 1995/1996 Cañon Creek experienced a flood that removed the riparian canopy in the lower reaches of the stream. Prior to the flood in 1994 and 1995 this reach had 7DMAVG temperatures of 16.7°C and 16.9°C, respectively. For the last 5 years following the flood, the 7DMAVG temperatures have exceeded 17.4°C. With the loss of the streamside vegetation, there was a greater proportion of the stream surface exposed to direct solar radiation. Low discharge in this lower reach also exacerbates the high stream temperatures. However, the general trend since the flood has been a gradual recovery of the riparian canopy and a decrease of the highest 7DMAVG stream temperatures.

#### **C5.1.2.5 Conclusions**

Green Diamond believes that a single threshold value fails to accurately represent the natural variation found in water temperature between sites. For this reason, future water temperatures will be evaluated based on the yellow and red light thresholds described in Section 6.3. The expected temperature for a site will be based on its watershed size rather than a generic threshold value applied equally to all streams.

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## **C5.2 CLASS II PAIRED WATERSHED TEMPERATURE MONITORING**

### **C5.2.1 Retrospective Study**

#### ***C5.2.1.1 Objectives and Methods***

The first study was a retrospective study of water temperature conducted during the summer of 1995. For this study, groups of small headwater streams in close proximity with similar flow, aspect, and geology were selected. One group of streams were direct

tributaries of the Mad River, while the other streams within Green Diamond's ownership were tributaries of Rowdy and Dominie Creeks in the Smith River watershed (Table C5-13). The streams differed in that some flowed through areas that had been recently harvested by clearcutting (cut) on both sides of the stream with Green Diamond's riparian buffers (standard state regulated widths but minimum 70% total canopy retention) left along the streams, while the other streams (uncut) were located in intact stands of second growth. One stream had only been harvested on one side (1/2 cut), but it was included with the cut group for analysis. In an attempt to see if there was a coastal effect in the results, Green Diamond also collaborated with the Hoopa Tribal Forestry to conduct the same type of study on similar sized streams within the Hoopa Reservation. A wide variety of silvicultural practices and riparian buffers have been implemented on the Hoopa Reservation over the years, so they selected sites that most resembled Green Diamond's silviculture and riparian leave standards. HOBO thermographs were placed in a total of 11 cut streams and 10 uncut streams. However, two of the HOBOS in cut streams were placed in reaches that went dry during the study, and one of the HOBOS in an uncut stream was removed by some unknown person during the study. The restrictions of finding comparable sites within the Hoopa Reservation limited the interior area to only three cut and two uncut streams (Table C5-13).

**Table C5-13. List of uncut and cut tributaries with watershed area (acres), stream orientation (aspect in °), adjacent stand age (years for uncut, feet for cut), and cover type (RW=redwood, DF=Douglas-fir), mean and mean maximum water temperature (°C) with standard deviations.<sup>1</sup>**

<b>Uncut</b>	<b>Area</b>	<b>Aspect</b>	<b>Adjacent Stand</b>	<b>Mean Temp</b>	<b>Mean Max.</b>
MR #4	74	46	70, RW	13.2 (1.05)	14.7 (0.73)
MR #5	338	19	70, RW	12.8 (0.60)	13.7 (0.38)
MR #7	160	344	70, RW	12.5 (0.63)	13.6 (0.46)
Rowdy #2	28	291	35-40, RW	12.7 (0.39)	13.1 (0.50)
Rowdy #3	78	159	35-40, RW	12.1 (0.45)	12.6 (0.55)
Dominie #3	46	345	45-50, RW	12.9 (0.91)	14.4 (1.01)
Dominie #4	7	210	45-50, RW	12.9 (0.79)	14.0 (1.00)
Hoopa #1	28	30	35-40, DF	13.5 (0.57)	14.1 (0.82)
Hoopa #6	338	100	*10-15/OG, DF	12.2 (1.23)	13.3 (1.46)
<b>Cut</b>	<b>Area</b>	<b>Aspect</b>	<b>Adjacent Stand</b>	<b>Mean Temp</b>	<b>Mean Max.</b>
MR #1	28	39	1400	12.4 (0.42)	13.0 (0.31)
MR #2	46	24	1900	13.2 (0.73)	14.7 (0.44)
MR #3	38	15	**1100/70, DF	12.2 (0.23)	12.6 (0.21)
MR #6	234	6	2700	12.8 (0.56)	13.7 (0.33)
Rowdy #1	22	255	1200	12.5 (0.64)	13.4 (0.83)
Dominie #1	37	298	1000	12.5 (0.62)	13.3 (0.74)
Hoopa #2	46	22	1500	13.3 (1.45)	14.6 (1.82)
Hoopa #3	38	107	1000	11.8 (1.01)	12.9 (1.14)
Hoopa #5	234	80	600	11.1 (0.55)	11.6 (0.70)

**Notes**

1 For cut tributaries, all variables are the same except that the adjacent stand description is replaced with the length (feet) of clearcut on both sides of the stream. Cover types of the riparian buffers of the cut tributaries were presumed to be the same as the corresponding uncut tributaries.

\* West side was 10-15 year old second growth and the east side was old growth.

\*\* West side was clearcut and the east side had 70 year old second growth.



In all cases, HOBOs were placed at the lower end of the cut unit, or in the same respective location on the uncut streams. Prior to placement, the HOBOs for each region were tested in a water bath to insure that they were all giving readings that were within the manufactures specified limits (plus or minus 0.2° C) relative to each other. However, they were not calibrated to a known standard (ice bath) to insure that the readings were accurate. For each region, the seven consecutive warmest days of the season were selected and the mean maximum and overall mean water temperatures for the period were calculated. Differences between means and variances of the two groups of streams were tested using a two-sample t-test (NCSS 1997).

### **C5.2.1.2 Results**

Visual inspection of HOBO data output from the two groups of streams did not reveal any consistent trends. The coldest streams with the least daily variation appeared to be Mad River #3 (1/2 cut), Rowdy #3 (uncut) and Hoopa #5 (cut). The warmest streams with the greatest daily extremes in temperature were Mad River #4 (uncut), Dominie #3 (uncut), Dominie #4 (uncut) and Hoopa # 2 (cut). In general, a visual ranking of all of the streams would indicate that prior timber harvesting did not correlate well with either the mean values or amount of variation in stream temperatures. Analysis of the data also indicated that there was no significant difference between the mean maximum ( $t = 0.74$ , d.f. = 16,  $P = 0.471$ ) or overall mean ( $t = 1.34$ , d.f. = 16,  $P = 0.199$ ) temperatures for the cut and uncut groups (see below).

Stream Groups	N	Mean Temp (°C)	S.E.	Mean Max. (°C)	S.E.
Uncut	9	13.51	0.192	14.19	0.283
Cut	9	13.11	0.227	13.85	0.352

There were too few streams available to make a meaningful comparison of uncut and cut streams in the more interior Hoopa Reservation, but a comparison was made between all coastal and all interior (Hoopa) streams. The temperatures of the five Hoopa streams (mean max. = 14.25; overall mean = 13.33) were similar to the 13 coastal streams (mean max. = 13.93; overall mean = 13.30), with no significant difference (mean max:  $t = 0.68$ , d.f. = 16,  $P = 0.508$ ; overall mean:  $t = 0.94$ , d.f. = 16,  $P = 0.363$ ).

This retrospective comparison of stream temperatures in cut versus uncut streams provided evidence that timber harvest was not having a substantial impact on stream temperature. Increasing the sample size of the two groups would have increased confidence in the conclusion that as a group, streams with riparian buffers on Green Diamond's ownership were not warmer than streams that were flowing through uncut areas. However, it did not permit a comparison of more subtle changes in stream temperature following timber harvesting. Since the inherent differences in stream temperatures between the two groups of streams was not known prior to harvesting, it was not possible to directly assess the changes that might have occurred. Due to the fundamental limitations of a retrospective study, Green Diamond concluded that continuing these comparisons between cut and uncut streams would provide little additional information and discontinued the study.

## **C5.2.2 Before-After-Control-Impact (BACI) Water Temperature Study**

### **C5.2.2.1 Objectives and Methods**

In summer 1996, Green Diamond initiated a monitoring program in non-fish bearing (Class II) watercourses to assess the adequacy of riparian buffers in maintaining water temperatures following timber harvest. Streams in areas where timber harvest was planned were identified and paired with streams in close proximity that had similar size, aspect, and streambed geology. The objective of this study was to examine the impact of timber harvest on water temperature in small Class II watercourses by comparing maximum temperature differentials between fixed upper and lower points of selected stream reaches. These temperature differentials were measured on matched pairs of streams, one member of which was scheduled for timber harvest, while the other was to be left undisturbed. The paired stream design was adopted to control for confounding factors that can influence water temperature such as ground water inputs and microclimatic factors. Measurements were initiated in both streams of a pair at least one year prior to timber harvest. These data represent a before-after-control-impact (BACI) (Green 1979; Stewart-Oaten et al. 1986; Skalski and Robson 1992) observational study. While observational studies cannot infer cause and effect relationships, BACI studies represent the best available setup for detecting changes after disturbance. Monitoring of the stream pairs is scheduled to continue at least three years after harvest, or until the temperature profile of the two streams return to the pre-treatment pattern. However, the data reported here only represent a preliminary assessment of data collected from 1996-1998. Analysis of 1999 and 2000 data is currently in progress.

For each pair of streams, the stream located in a future harvest unit was designated as the "treatment" stream, while the other stream was designated as the "control" stream. Two remote temperature data loggers were placed in the treatment stream at the upstream and downstream edges of the harvest unit. Another pair of temperature recording devices was placed in the control stream at locations that were similar in stream spacing (distance apart) and watershed position relative to the treatment stream. Treatments consisted of clearcuts placed on both sides of the stream with standard forest practice buffer widths (50-75 feet) and 70% total canopy retention. Each stream pair is referred to as a *site*.

The five sites selected in 1996 include:

- One pair in the headwaters of Dominie Creek (D1120) in the Smith River HPA ;
- One pair of tributaries to the South Fork Winchuck River (D1120 in the Smith River HPA ;
- One pair in the headwater tributaries of the Little River (Mitsui) in the Little River HPA;
- One pair off the mainstem Mad River in the Mad River HPA; and
- One pair in the headwater tributaries of Dominie Creek in the Mad River HPA.

In 1999, three pairs were added to the study:

- Two pairs of tributaries to Maple Creek (Windy Point and M1) in the Mad River HPA; and
- One pair of tributaries to the Lower South Fork Little River (M155) in the Little River HPA.

Timber harvest at Mitsui and D2010 took place in winter 1996/1997. Timber harvest at 6001 and 5410 took place in winter 1997/1998. As of winter 1999/2000, timber harvest had not yet occurred at D1120. Timber harvest at Mitsui and D2010 took place in winter 1996/1997. Timber harvest at 6001 and 5410 took place in winter 1997/1998. The Maple Creek units were harvested in winter 1999/2000. As of winter 1999/2000, timber harvest had not occurred at D1120 or the Lower South Fork unit.

The study is still in its data collection phase on pairs where the treatment site was harvested after 1999 or has yet to be harvested. However, a preliminary analysis has been conducted of data from the four pairs harvested before 1999 (Mitsui, D2010, 6001, and 5410).

As indicated in Table C5-14, mean length of control and treatment reaches on Mitsui, D2010, 6001, and 5410 was 1069.2 feet (SE = 515.71) and 1210.2 feet (SE = 650.63), respectively. Mean percent canopy closure following timber harvest was 79.8 (SE = 5.27) and 75.2 (SE = 3.70) for control and treatment reaches, respectively, but the difference was not statistically significant ( $P < 0.05$ ) using a one-tailed paired t-test ( $t = 1.73$ , d.f. = 3,  $P = 0.091$ ).

The upstream and downstream placement of temperature recording devices allowed measurement of the temperature differential across the treatment area and an assessment of the extent to which water temperature changed as it flowed through the treatment area. Interest was primarily in quantifying increases in water temperature as it flowed through the treatment area compared to similar measurements in the control stream reach.

Temperature recording devices were calibrated prior to deployment. For calibration, all data loggers (mostly HOBOS initially and later TidbiTs) were placed in an ice bath and temperature readings were taken after three hours. Pairs of data recorders for upstream and downstream deployment on the same stream were formed by pairing instruments with identical readings after three hours in the ice bath. The manufacturer's specification limit was  $0.2^{\circ}\text{C}$ . All recorders were programmed to record temperature ( $^{\circ}\text{C}$ ) every 1.2 hours or 20 times every 24 hours. For this analysis, data were recorded on five pairs of streams.

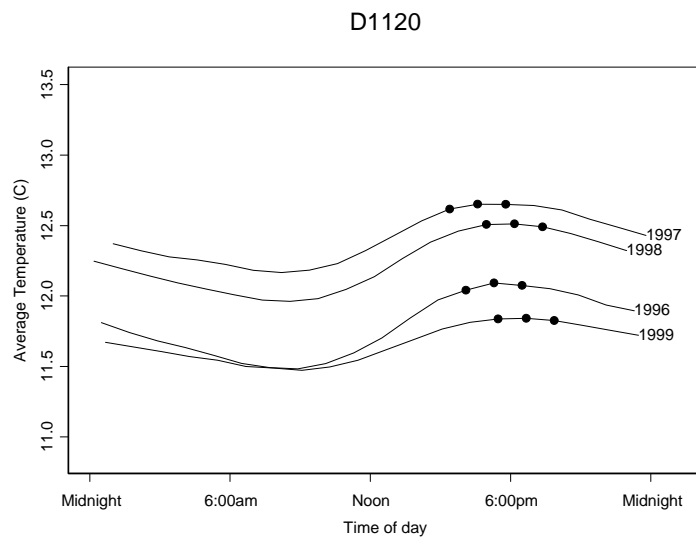
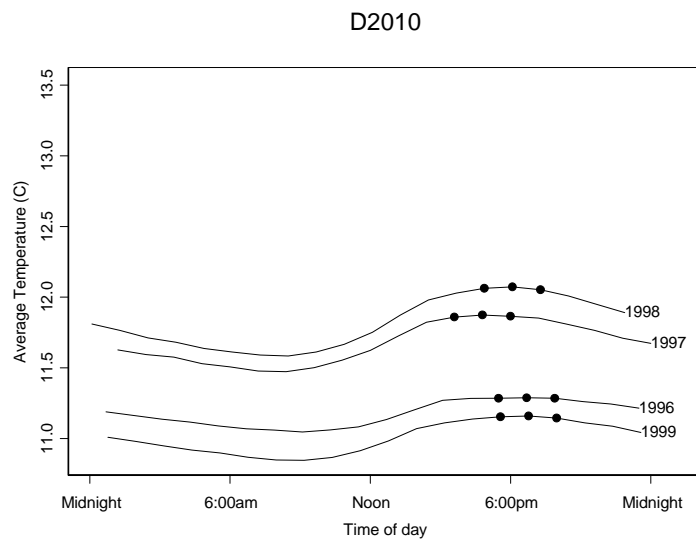
**Table C5-14. Initial five pairs in the Class II BACI study, with stream reach length, mean canopy closure throughout the reach, and aspect.**

Stream (Drainage)	Type of Treatment	Reach Length (ft)	Canopy Closure (%)	Aspect (°)
5410 (Dry Creek)-	Control	1755	81	320
5410 (Dry Creek)-	Harvested	2090	73	0
6001 (Mad River)+	Control	541	74	10
6001 (Mad River)+	Harvested	764	69	55
Mitsui (Little River)-	Control	856	70	285
Mitsui (Little River)-	Harvested	1312	73	330
D1120 (Dominie Creek)	Control	1605	95	185
D1120 (Dominie Creek)	Scheduled for harvest	*1625	95	200
D2010 (SF Winchuck)+	Control	1125	94	345
D2010 (SF Winchuck)+	Harvested	675	86	350
<b>Note</b> *Asterisks on the reach length for the D1120 indicate the expected length of stream that will be adjacent to the scheduled harvest.				

Data loggers were deployed in all streams by early summer each year and collected after 15 September. For analysis, attention was restricted to the time period 1 August to 15 September. This time period is generally the warmest time of year in Northern California. Upstream and downstream temperatures collected on a single stream were matched according to the time of day they were recorded and the difference between them (downstream - upstream) was calculated every 1.2 hours. To identify a response variable that quantified the amount of heat gain produced in the treatment area, intra-day temperature profiles were computed that identified the warmest time of day for each stream each year. The three temperature readings closest to the warmest time of day for each stream were defined to be the *maximum temperature window*. The intra-day temperature profiles used to define the maximum temperature window and, consequently, the daily maximum temperature differences appear in Figure C5-1. In Figure C5-1, values from all four temperature probes (i.e., the upstream and downstream probes on both the treatment and control streams) were averaged every 1.2 hours to arrive at an estimate of overall average water temperature. The three readings that defined the maximum temperature window for each stream each year have been plotted as circles in Figure C5-1. Across streams and years, the maximum temperature window varied from 2:00 pm to 9:07 pm. The warmest time of day for the five study sites was, on average, 5:45 pm.

The maximum downstream – upstream temperature difference that occurred within the daily maximum temperature window was computed and used as the response variable in the BACI analysis. For example, suppose that the three temperature readings nearest to the warmest time of day at a stream occurred at 5:00 pm, 6:12 pm, and 7:24 pm. For each day between 1 August and 15 September, the difference between the downstream and upstream probe at 5:00 pm, 6:12 pm, and 7:24 pm was computed. The maximum of these three differences was used as the response variable in the BACI analysis for that particular day. One maximum difference was computed for each day.

**Figure C5-1.** Initial five study sites shown below with smoothed daily water temperature profiles computed from the mean of all four temperature probes (i.e. upstream and downstream from the treatment and control streams). Dots show recordings defining the daily maximum temperature window for each site.

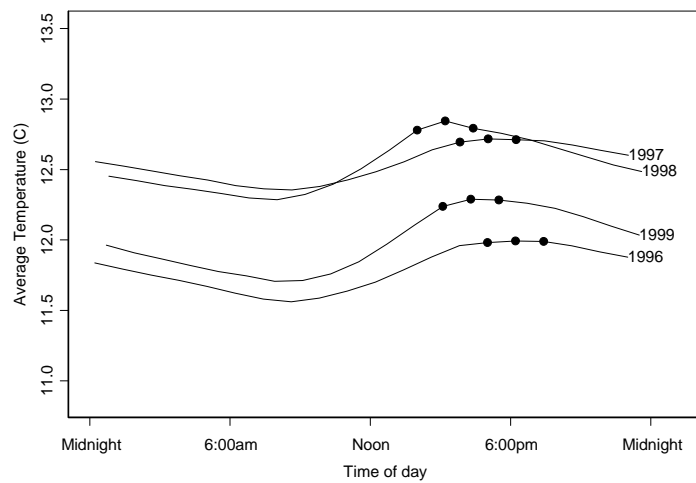


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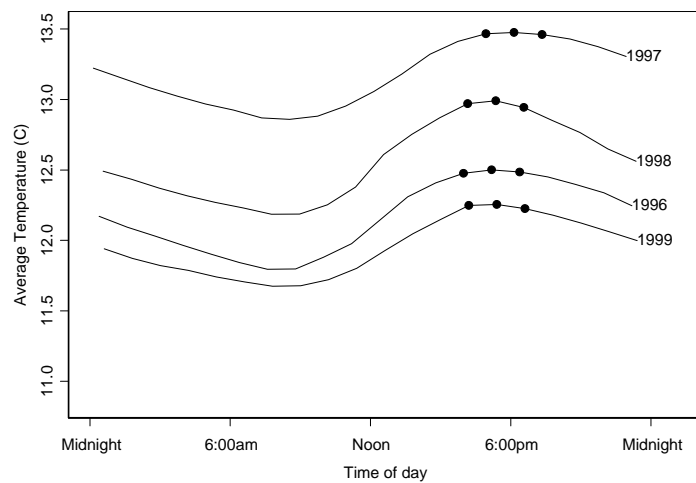
GREEN DIAMOND  
AHCP/CCAA

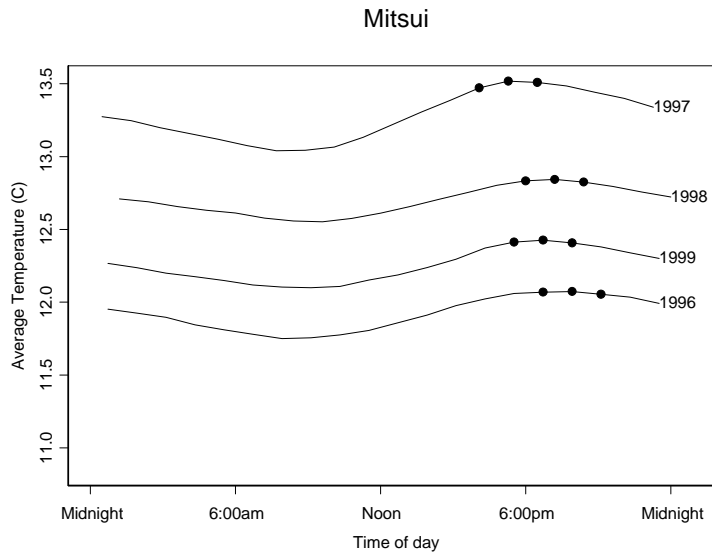
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6001



5410





Given the serial nature of the daily temperature recordings, the data were assessed for temporal auto-correlation. Significant auto-correlation existed in the yearly time series of maximum temperature differentials at each site. Where significant auto-correlation was found, error estimates were adjusted to correct for the estimated auto-correlations. (See Attachment A below for details.)

The statistical analysis used to assess harvest impacts was a modified BACI analysis. The modification was made necessary due to the estimated auto-correlations in the daily temperature recordings. BACI analyses assess the lack of parallelness in response profiles through time. This lack of parallelness was measured by the treatment by time (year) interaction from an analysis of variance (ANOVA) with time as one factor and treatment as the other. The BACI analysis allows the overall level of responses to be different between control and treated sites both before and after treatment, but requires the after treatment *difference* in control and treated responses to be the same as the before treatment *difference* in control and treated responses. If the after treatment difference in responses is different from the before treatment difference in responses, the BACI analysis will show that there was significant change in treatment areas after application. Differences between sites in the direction and magnitude of temperature changes after harvest became apparent upon plotting of the data. Given the variability in which individual streams responded to the treatment, each site was analyzed separately and no statistical inference to other sites was possible. Additional information on the use of ANOVA in the BACI estimation process can be found in McDonald et al. (2000). Additional details specific to this study can be found in Attachment A below.

#### **C5.2.2.2 Results of Preliminary Analysis**

Significant auto-correlation existed in the yearly time series of maximum temperature differential at each site. Estimated correlation of maximum temperature differential values that were one day apart ranged from 0.49 at D1120 to 0.81 at 5410. Auto-correlation at D2010, D1120, and 6001 was negligible between values separated by

more than 5 days. Auto-correlation at 5410 and Mitsui was negligible between values separated by 13 or more days.

Table C5-15 contains estimated mean maximum temperature difference and standard errors between the downstream and upstream temperature probes for all streams each year of the study. Means and standard errors in Table C5-15 were estimated from the BACI model adjusting for auto-correlation. Positive values indicate that the average maximum downstream temperature was warmer than the upstream temperature, while negative numbers indicate the reverse. Average heating or cooling between the upstream and downstream probes was variable.

Table C5-16 contains estimated average maximum temperature differences before and after timber harvest. (D1120 is missing from Table C5-16, because it had not yet been harvested.) After harvest, D2010 and 6001 experienced an increase in the maximum temperature differential, while Mitsui and 5410 experienced a decrease relative to their control streams. The 95% confidence intervals for the increases at D2010 and 6001, and decreases at Mitsui and 5410 did not include zero and therefore should be considered “significantly” different from zero.

D1120 was not harvested during the course of data collection and provided a check of the appropriateness of BACI analysis. Under similar conditions, the BACI analysis hypothesizes that the profile of temperature responses through time on the treatment and control streams should, within statistical error, be parallel to one another. Figure C5-2 plots the estimated profile of average maximum temperature differential across years for D1120. Assuming a hypothetical harvest occurred in winter 1996/1997, the estimated change in maximum temperature differential on the hypothetical treatment stream was  $0.013^{\circ}\text{C}$  with approximate 95% confidence interval of  $-0.149^{\circ}\text{C}$  to  $0.175^{\circ}\text{C}$ . Applying the same hypothetical treatment to the following year, the estimated change in maximum temperature differential on the hypothetical treatment stream was  $-0.082^{\circ}\text{C}$  with approximate 95% confidence interval of  $-0.223^{\circ}\text{C}$  to  $0.058^{\circ}\text{C}$ . The profiles plotted in Figure C5-2 are parallel within the limits of statistical error, because the associated confidence intervals contain zero.

Plots of the estimated mean maximum downstream-upstream differences from Table C5-15 were plotted in Figure C5-3 below along with the average maximum temperature differential expected by the BACI analysis had there been no harvest. With no treatment effect, the expected mean treatment profiles were parallel to the control stream profile.



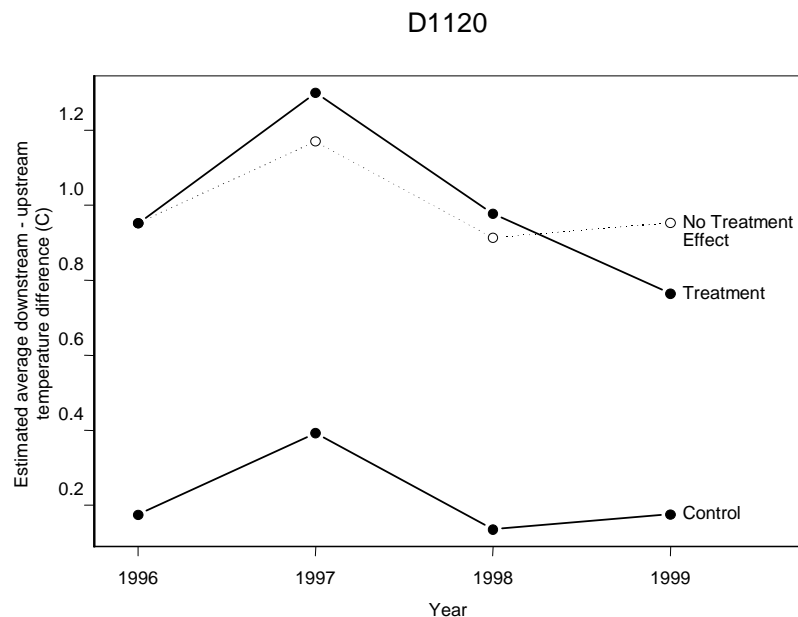
**Table C5- 15. Yearly estimated mean maximum downstream-upstream temperature differences of the initial five sites. <sup>1</sup>**

Mean Maximum Downstream-Upstream Temperature Difference, °C			
Stream	Year	Treatment Stream (SE)	Control Stream (SE)
D2010	1996	0.839 (0.101)	0.991 (0.101)
	1997	1.601 (0.101)	1.436 (0.101)
	1998	1.705 (0.101)	1.029 (0.101)
	1999	1.288 (0.101)	1.234 (0.101)
D1120	1996	0.952 (0.051)	0.175 (0.051)
	1997	1.300 (0.051)	0.393 (0.051)
	1998	0.977 (0.051)	0.136 (0.051)
	1999	0.764 (0.051)	0.176 (0.051)
6001	1996	0.392 (0.087)	0.240 (0.087)
	1997	0.787 (0.087)	0.293 (0.083)
	1998	1.484 (0.087)	0.226 (0.083)
	1999	1.227 (0.088)	-0.243 (0.088)
5410	1996	0.316 (0.099)	1.227 (0.099)
	1998	-0.026 (0.095)	1.423 (0.095)
	1999	-0.041 (0.101)	1.480 (0.101)
Mitsui	1996	-0.146 (0.125)	-0.071 (0.125)
	1997	-0.928 (0.125)	0.135 (0.125)
	1998	-1.294 (0.125)	0.007 (0.125)
<b>Note</b>			
<sup>1</sup> All measurements in Celsius. Standard errors estimated from BACI model.			

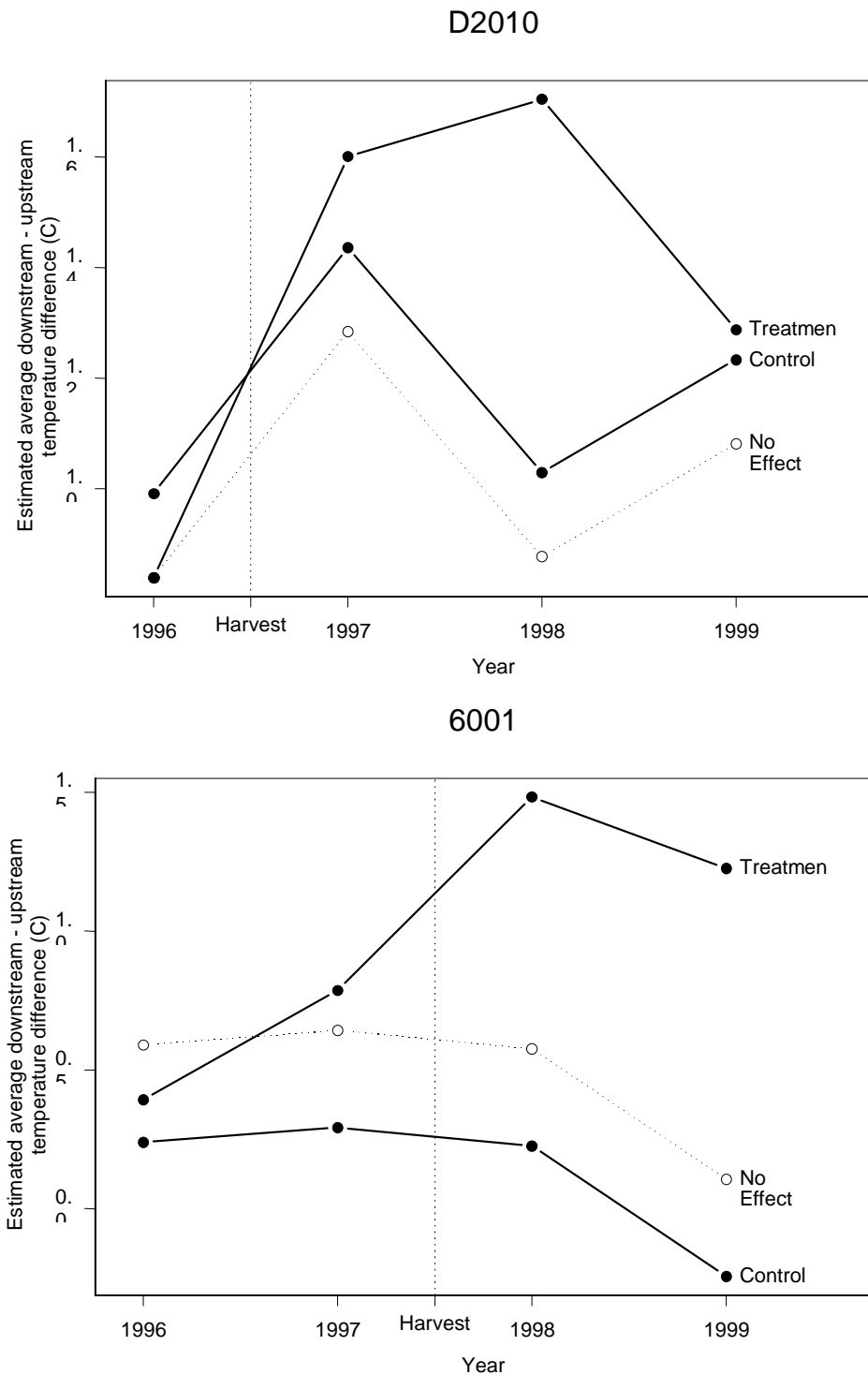
**Table C5-16. Estimated average maximum temperature differences before and after harvest on four sites where harvesting occurred prior to 1999. <sup>1</sup>**

Stream	Harvest Period	Estimated Average Maximum Temperature Difference, °C		Estimated Change After Harvest, °C (SE)	Approximate 95% Confidence Interval on Increase
		Treatment (SE)	Control (SE)		
D2010	Before	0.756 (0.098)	0.898 (0.098)	0.497 (0.16)	0.182 to 0.811
	After	1.515 (0.057)	1.16 (0.057)		
6001	Before	0.535 (0.061)	0.139 (0.061)	1.044 (0.123)	0.803 to 1.286
	After	1.323 (0.062)	-0.117 (0.062)		
5410	Before	0.178 (0.139)	0.486 (0.139)	-1.372 (0.239)	-1.84 to -0.904
	After	-0.368 (0.096)	1.312 (0.096)		
Mitsui	Before	-0.214 (0.129)	-0.222 (0.129)	-1.31 (0.224)	-1.748 to -0.871
	After	-1.28 (0.091)	0.022 (0.091)		
<b>Note</b>					
1 Values of change after harvest (Column 5) quantify the lack of parallelism in temperature differential profiles and are equal to the interaction effects in the BACI ANOVA. For example, at D2010 estimated change after harvest equaled 0.497 = (1.515-0.756)-(1.16-0.898). Positive numbers for change after harvest indicate heating of the treatment section after harvest relative to the control section. Negative numbers indicate cooling of the treatment section after harvest relative to the control section.					

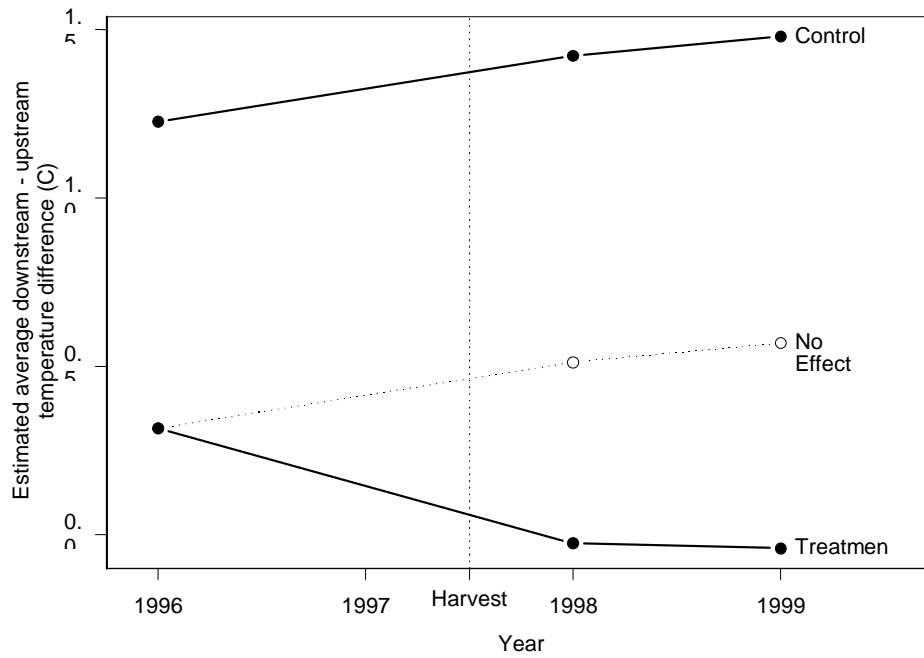
**Figure C5-2. Estimated means at D1120 where no harvest has occurred. Hollow circles and dashed line indicate perfect parallelness between treatment and control streams. Filled circles show actual estimates.**



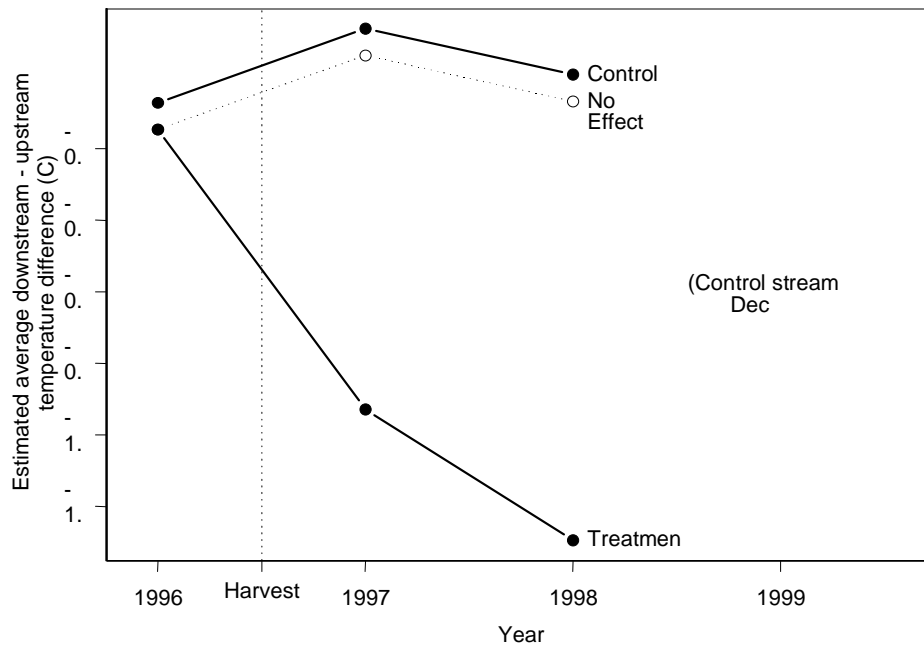
**Figure C5-3.** Estimated means before and after harvest from the BACI model adjusted for auto-correlation. Filled circles show actual estimates, while hollow circles show locations of treatment means under the hypothesis of no treatment effect. Monitoring stopped in 1998 at Mitsui, because timber surrounding the control stream was harvested during winter 1998.



5410



Mitsui



### **C5.2.2.3 Discussion**

The impacts of timber harvest on water temperature on small Class II watercourses were assessed at the warmest time of day during the warmest time of the year. This was done to insure the maximum test of the effectiveness of riparian buffers in mitigating the potential impacts of increased water temperatures following clearcut timber harvest adjacent to a watercourse. In addition, the assessment was focused on the warmest time of the year, since it is believed that the Covered Species are most likely to be impacted by increases in water temperature that may cause water temperature to exceed some biological threshold. It is also important to note that the retention standards on the riparian buffers were significantly less than what is being proposed in the AHCP. The riparian buffers all followed standard forest practice widths, but with Green Diamond's minimum 70% total canopy retention (retention standard created by Green Diamond's NSO HCP).

Empirical data and theoretical models of water temperature profiles indicate that water temperature generally increases in most watersheds as water flows downstream during the warmest times of the year (Beschta et al. 1987). Increases in the water temperature are the result of multiple factors, but typically most of the increased thermal energy of the water results from the air temperature being elevated relative to the water temperature. The rate of increase is largely a function of the temperature differential between air and water. Therefore, if air temperature increases in the riparian areas following timber harvest, one would predict an increase in the rate at which water temperature warms as it flows downstream through the harvested area.

The thermal profiles of the monitored streams indicated that the changes in water temperature as it flowed downstream was a rather complex process and did not always fit the pattern of increased warming as water flowed downstream. As noted in Table C5-16, mean water temperature decreased rather than increased as it flowed downstream during at least one year in four of the ten streams. Monitoring reaches were selected to insure that tributaries did not enter within the sample reach, so these decreases were most likely due to ground water inputs or changes in the microclimate within the stream reach.

Fortunately, this study was designed using a BACI approach, which controlled for unexpected patterns in the thermal profiles of either the treatment or control streams. All that was necessary for a valid experiment was for the relationship between treatment and control streams to remain constant through time minus a treatment effect. The results from the D1120 (Figure C5-2) provided support that this assumption was valid.

The data from this study are preliminary, but already it is apparent that the response of water temperature to timber harvest in small headwater streams is complex. All of the treatment streams showed a significant change in water temperature relative to the controls streams following timber harvest, but in two of the sites, the treatment streams were warmer while the other two were colder. There are no other data to help provide clues as to why these sites responded in opposite directions to timber harvest, but Green Diamond speculates that it may be due to altered hydrology. Clearcutting adjacent to a stream should increase the amount of water that is retained in the soil for a few years following harvest primarily due to a reduction of evapotranspiration water

losses. If some treatment streams had groundwater inputs while others did not, it would be possible that the increased groundwater could result in relatively cooler water temperatures following harvest in those treatment streams with groundwater inputs. Those treatment streams without significant groundwater inputs would have the greater potential to experience increases in water temperature following harvest. If this pattern persists in additional monitored sites, one would conclude that the cumulative effect of timber harvest on water temperature in small Class II watercourses within a watershed should net to zero.

The retrospective study of water temperature did not allow us to assess changes in water temperature following timber harvest, but the results were consistent with the observations of the BACI study. Cut and uncut streams varied in terms of which streams were colder and there was no statistical difference in the mean values for the streams.

It is also important to note that the magnitude of the differences following harvest, regardless their direction, were quite small (about 0.5 to 1.4°C) even though the streams were being analyzed during the annual extremes in elevated water temperatures. In addition, the peaks in water temperature only lasted a few hours in the late afternoon and early evening. Green Diamond believes that it is unlikely that the magnitude of these temperatures would have a biological impact on any of the Covered Species given the 7DMMX reported for most of the Class II watercourses within the Plan Area. (See Water Temperature Monitoring above.)

#### **C5.2.2.4 Conclusions**

The Class II water temperature monitoring is in the early phases of a long term study that will include additional sites along with additional post-harvest monitoring on the existing sites. As such, these data should be considered preliminary. However, pre-AHCP mitigation measures associated with small Class II watercourses appear to prevent large magnitude changes in water temperature following timber harvest. Presumably, the increased protection measures afforded Class II watercourses in the AHCP will further reduce the likelihood of temperature impacts due to timber harvest. Green Diamond believes that the small magnitude and reversed direction of the temperature changes following timber harvest will not result in any direct or cumulative biological impacts on any of the Covered Species.

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## **C5.2.4 Attachment A to BACI Class II Temperature Monitoring**

This attachment describes estimation of the BACI model and correction for auto-correlation in the data. The analysis is described in three steps; 1) ordinary least squares parameter estimation, 2) auto-correlation modeling, and 3) weighted linear regression.

### **C5.2.4.1 Ordinary Least Squares Parameter Estimation**

Step one of the analysis fit a Normal theory regression model to indicator variables delineating treatment and control observations and before and after observations. Let  $x_{ti}$  be an indicator variable whose value was 1 if observation  $i$  came from the treatment stream, 0 otherwise. Let  $x_{97i}$  be an indicator variable whose value was 1 if observation  $i$  was collected in 1997, 0 otherwise. Similarly, let  $x_{98i}$  be an indicator function with value 1 if observation  $i$  was collected in 1998 and let  $x_{99i}$  be an indicator function with value 1 if observation  $i$  was collected in 1999. Step one of the analysis fit the regression model,

$$E[y_i] = \beta_0 + \beta_1 x_{ti} + \beta_2 x_{97i} + \beta_3 x_{98i} + \beta_4 x_{99i} + \beta_5 x_{ti} x_{97i} + \beta_6 x_{ti} x_{98i} + \beta_7 x_{ti} x_{99i}$$

where  $y_i$  was the maximum difference between downstream and upstream temperature readings on day  $i$  that occurred during the maximum temperature window.

Estimates of the overall before-after control-impact interaction (i.e., the difference of differences in means) were computed using contrasts of coefficients in the model (McDonald et al., 2000). For example, the overall BACI contrast for a pair of streams harvested in winter 1996/1997 was,

$$\text{BACI}_{96} = -1/3\beta_5 - 1/3\beta_6 - 1/3\beta_7$$

The overall BACI contrast for a pair of streams harvested in winter 1997/1998 was,

$$\text{BACI}_{97} = 1/2\beta_5 - 1/2\beta_6 - 1/2\beta_7$$

Let  $\mu_{BT}$  be the mean response on the treatment stream before treatment. Let  $\mu_{BC}$  be the mean response on the control stream before treatment. Let  $\mu_{AT}$  be the mean response on the treatment stream after treatment, and let  $\mu_{AC}$  be the mean response on the control stream after treatment. The BACI contrasts listed above both estimate,

$$(\mu_{BT} - \mu_{BC}) - (\mu_{AT} - \mu_{AC})$$

The negative of these BACI contrasts appear in column 5 of Table C5-16 above.

#### **C5.2.4.2 Auto-correlation Modeling**

Step two of the analysis assessed and modeled auto-correlations among residuals of the regression fit during step one. No auto-correlations were checked among residuals from different streams or different years. Auto-correlations among residuals from different stream or years were assumed to be zero. If significant auto-correlation were found in the residuals of the regression model, a non-linear variance model was fit to the correlations and an estimated residual variance-covariance matrix was constructed. The variance model used at this step was of such a form that non-singularity of the resulting variance-covariance matrix was assured.

The significance of auto-correlations among residuals of the original model were assessed using Moran's I (Moran, 1950) statistic at various separations in time (time lags). If a (Bonferroni corrected) 95% confidence interval surrounding Moran's I did not overlap zero, the auto-correlation was deemed significant.

Provided significant auto-correlations existed, a *spherical* correlation model was fit to observed correlations. The spherical variance model was fit by forming all possible pairs of residuals and calculating the statistics  $z_{ij} = (r_i - \mu_r)(r_j - \mu_r)/s_r^2$ , where  $r_i$  was the model residual from the  $i$ -th observation and  $s_r^2$  the sample variance of the residuals. The  $z_{ij}$  were then plotted against the time between observation  $i$  and observation  $j$  to form a correlation scatter gram. The correlation scatter gram was then smoothed using a Gaussian kernel smoother (Venables and Ripley, 1994; Statistical Sciences, 1995). The spherical correlation model was fit to the smoothed correlation scatter gram using non-linear least squares techniques. The spherical correlation model contained two parameters and had the form,

$$v(d_{ij}) = \begin{cases} c_1 \left( 1 - \frac{3}{2} \frac{d_{ij}}{h_0} + \frac{1}{2} \left( \frac{d_{ij}}{h_0} \right)^3 \right) & \text{if } 0 \leq d_{ij} \leq h_0 \\ 0 & \text{if } d_{ij} > h_0 \end{cases}$$

where  $d_{ij}$  was the time between observation  $i$  and  $j$ . Based on the significance of auto-correlations beyond 20 days, only  $d_{ij}$  less than 20 days were considered when fitting the spherical model.

#### **C5.2.4.3 Weighted Linear Regression**

Step three of the analysis used the estimated residual variance-covariance matrix from step 2 as a weight matrix to recompute the coefficients of the regression model obtained



at step one. Standard errors for coefficients and contrasts were also recomputed using elements of the estimated variance-covariance matrix as weights. Specifically, if  $\mathbf{X}$  was the design matrix containing the indicator variables used in the regression model at step one,  $\mathbf{Y}$  was the vector of responses, and  $\mathbf{V}$  was the estimated residual variance-covariance matrix obtained at step two, then the recomputed vector of coefficients,  $\hat{\beta}$ , and variances were,

$$\hat{\beta} = (\mathbf{X}'\mathbf{V}^{-1}\mathbf{X})^{-1}\mathbf{X}'\mathbf{V}^{-1}\mathbf{Y}$$
$$\text{var}(\hat{\beta}) = (\mathbf{X}'\mathbf{V}^{-1}\mathbf{X})^{-1}.$$

In this study, interest was in the BACI contrasts defined above. Variance of the BACI contrasts were computed as,

$$\text{var}(\text{BACI}) = \text{var}(\mathbf{x}\hat{\beta}) = \mathbf{x}(\mathbf{X}'\mathbf{V}^{-1}\mathbf{X})^{-1}\mathbf{x}'$$

where  $\mathbf{x}$  was the vector of constants defining the contrast.

